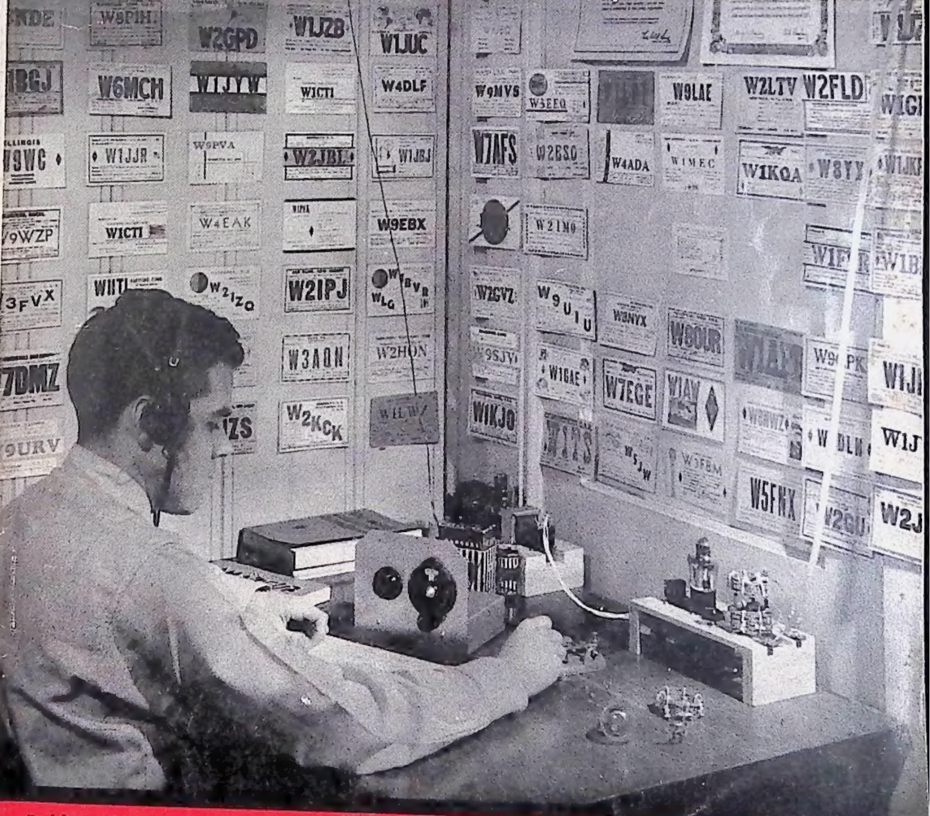
SIMPLE RECEIVERS AND TRANSMITTERS

How to

BECOME A RADIO AMATEUR

50¢

With Complete Constructional Details of Simple and Inexpensive Amateur Stations



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BECOME A RADIO AMATEUR

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How to Become A Radio Amateur

You are interested in radio and in the magic of radio communication. The thrill of direct two-way radio conversations with persons in foreign countries, of participating in emergency communications in time of disaster, of exploring the frontiers of radio development with equipment you build yourself — all these and more may be yours through the medium of amateur radio.

You probably know that there are people called "radio amateurs" who talk amongst themselves at all hours of the day and night. You may have heard them at certain settings on the dial of your all-wave receiver; you may have read of them in your daily newspaper after some flood or emergency in which they rendered great public service.

Who are radio amateurs? What *is* amateur radio?

Amateur radio is direct private experimental communication, from your own home, on apparatus you have usually built yourself, with other amateurs similarly equipped.

Anyone can become an amateur — boy or girl, man or woman — almost regardless of previous training and experience. All that is required is a sincere desire to learn and a little effort acquiring the necessary knowledge. Boys of 8 and 10 have become amateurs — as have men of 80. They come from all walks of life, their sole bond the fascination that the amateur game affords.

You may already know the thrill that comes from tuning in some distant station in a foreign land on an all-wave receiver But that is only a small part of the thrill that comes only to the radio amateur — the thrill not only of hearing foreign countries but also of throwing the switch on his own transmitter and talking with the stations he hears.

You would like to know how these people came to be amateurs, how they acquired the ability and the equipment to get on the air and talk. You might like to become an amateur yourself — at least you would like to know how to go about becoming one.

The purpose of this booklet is to tell you, as simply and straightforwardly as possible, what amateur radio is, how one can become an amateur, how to build a simple receiver and transmitter, and how to get on the air. But first let us explore some of the many possibilities amateur radio offers.

Adventure!

Each night's operation is a new adventure into space. An amateur's station — sometimes an elaborate affair that rivals the equipment of a big broadcasting station, more often an inexpensive outfit assembled at home in spare moments — becomes a modern Aladdin's lamp. You never know, when you sit down to your transmitter and receiver for a few hours' operation at the end of the day's work, what those hours will bring. Perhaps, to start, a few friendly chats with neighboring amateurs in near-by states. Some of these may be contacted for the first time that particular night; others may be amateurs who have been "worked" before and with whom regular schedules have been arranged once or twice a week. Following this there may be an opportunity to pass the time of day with a Virgin Islander or, later, a missionary afar in Africa or a weather observer on some faraway U. S. island in the Pacific. You may suddenly be asked to relay a message for assistance for a town even then being devastated by a hurricane, or have the experience, as many amateurs have, of exchanging signals with some far-off Arctic or Antarctic expedition.

Endless Variety

These are but a very few of the things that you, as an amateur, may do. The reason that amateur radio is often called the most satisfying and thrilling of all hobbies is that it offers something for everyone. It is, to use a familiar phrase, "all things to all men."

For example: You may be a "tinkerer" — you may like to play around with gadgets, build them up, make them work. Amateur radio is the ideal hobby for the tinkerer who likes to go into the "why" of the things he builds. It offers endless room for experiment, an infinite variety of problems to overcome. You may be a "rag-chewer." The most enjoyment you know may come from getting together with a crowd of good fellows and talking over everything under the sun. Amateur radio is full of confirmed addicts of the conversational art; indeed, there is even a "Rag-Chewer's Club," with a membership certificate signed by

"The Old Sock" himself, for those who can qualify.

Competition

You may have the competitive urge. If your biggest kick in life comes from putting everything you've got into some sport or game that requires a high order of intelligence and skill, amateur radio will provide plenty of activities to test your mettle. Every day in the year thousands of amateurs compete to see who can relay the most messages; elaborate traffic nets, with trunk lines, field officials and comprehensive organization have been established by the Communications Department of the American Radio Relay League. Hundreds of other amateurs compete with each other in working DX (distant) stations. DXing is actually a glorified form of fishing; it takes endless patience and skill, but to the true "fisherman" it has a zest nothing else in the world can equal — and it's a sport you can indulge in any day, any season of the year.

Beyond these daily activities there are dozens of contests of various kinds held annually. The biggest is the Sweepstakes, engaged in by amateurs all over the United States. Field Day brings thousands of amateurs into the countryside with portable self-powered equipment. In these, as in the smaller contests, amateurs compete not only on a national scale but locally.

But all this still does not convey the whole picture of amateur radio. If one is interested in Army or Navy activity, and is a member of the military reserves, he will find himself freely encouraged to join either the communications reserve of the U. S. Navy or the Military Affiliate Radio System, each of which conducts weekly "drills" over the air to train operators in the intricacies of military radio procedure. In the comprehensive field organization of the ARRL you may find satisfaction in an appointment as Official Observer, as a sort of voluntary policeman of the air, or as an Official Bulletin Station, transmitting the latest amateur news bulletins on regular schedules, or as an Official Experimental Station, helping solve the mysteries of the ultra-high frequencies.

Nor is all of amateur radio confined to contacts over the air or solitary experimentation. There are more than 700 active radio clubs in the country affiliated with the ARRL, and they offer programs of wide general interest. Each year several divisional conventions and some dozens of "hamfests" are held. Hundreds of amateurs attend these fraternal get-togethers, which last from an afternoon or evening to as much as three days. Not only are they instructive, not only do they permit amateurs to meet in person those they have talked with over the air, but they are mighty good fun, as well.

From Champions to Newsboys

This, then, is amateur radio. That its appeal is universal is demonstrated by the type of people that pursue it. A cross-section of amateur radio is a cross-section of any community. The popular myth that all amateurs are "attic experimenters" has no basis in fact. It is true, of course, that a considerable number of boys and girls under 20 do become amateurs, for it is one of the advantages of amateur radio that it is not too intricate or abstruse for young people of high school age to master. But if you, as an amateur, get on the air tonight or tomorrow night and contact other amateur stations you may find yourself talking with the son of a former President or a popular band leader or a famous radio comedian — or your newsboy or filling-station owner. . . The list could go on endlessly, but the point is that amateur radio is indeed a universal hobby, having an appeal to professional worker and artisan alike, to young as well as old.

Amateur radio is not a spontaneous development. It is the result of five decades of evolution. For 40 years it has been guided in technical and operating progress, and defended against legislative threat, by its national organization, the American Radio Relay League.

The League, which was founded in 1914, is the traditional spokesman for amateur radio. Numbering in its ranks a majority of the active licensed amateurs, it is operated as a mutual non-stock corporation, entirely amateur-owned and directed. Through a representative system of government, it makes the amateur body articulate in representation at Washington and at international radio conferences. Scores of times it has averted the threatened abolition of amateur work. From its headquarters at West Hartford, Conn. — where visitors are always welcome — where nearly sixty people are employed — it publishes the monthly journal of amateur radio, *QST*, as well as many amateur handbooks and booklets, all available at low cost to help amateurs obtain the greatest enjoyment from their hobby.

Licenses Essential

It is the law that no one can operate a radio transmitter without a license from the United States Government. All forms of radio are administered by a government agency at Washington called the Federal Communications Commission. The Commission assigns radio facilities to all types of radio stations — and often certain services feel that they require more space on the air. This competition, the necessity for every class of radio station to demonstrate that it is operated in the maximum of public interest, convenience and necessity, forces amateur radio — through the ARRL — to maintain a united front in order to preserve its rights.

The FCC requires that every amateur station and operator be licensed. There are heavy penalties for operation of an unlicensed station — a maximum of two years in jail and a fine of $10,000. As you read on in this booklet you will learn how the necessary licenses can be acquired and the other requirements met.

The Three Steps

There are three steps involved in the process of becoming an amateur. The first consists of learn-

ing something about radio; assembling a station — receiver, transmitter and antenna — and learning the code. The second step consists of acquiring a knowledge of amateur operating practices, customs, etc. The third is the acquiring of the government station and operator licenses which every amateur must have before his *transmitter* can be operated and, in connection with this step, the study of a small amount of basic radio theory and radio regulations to enable the applicant to pass the examination given every amateur.

The first two of these steps are covered completely in the pages of this booklet. Learning the code requires only a relatively small amount of application and mental effort, and thousands of amateurs have learned the code in the time-honored fashion we describe here. The rudiments of amateur customs and practices, operating procedure, etc., are given for your information. Detailed treatment of the third step is beyond the scope of this booklet; to cover licensing procedure and examination preparation thoroughly would perhaps double the size of this booklet. But manuals and texts are available on these subjects, and later on we will tell you what they are and where they may be obtained. Right now let us examine the short-wave portion of radio frequencies and find out where amateurs fit into the picture.

The Amateur Bands

While we may occasionally use the term *short waves* interchangeably with *high frequencies* (since they are the same), right at the start let's get used to figuring mostly in terms of frequencies, since practically all references these days are in those terms.

The range of usable radio frequencies, from 10 kilocycles to above 30,000,000 kilocycles, is known as the radio *spectrum*. The regular broadcast-band portion of the spectrum extends from 535 to 1605 kilocycles. When we speak of high frequencies we refer in general terms to the territory above the broadcast band — that is, 1600 kc. and up. Amateurs are assigned chunks of frequencies, or *bands*, at various places throughout the spectrum above 1600 kc.

Years ago there was a time when none of the commercial or government radio people thought that any of this territory was useful for communication purposes and, in fact, until the advent of vacuum tubes for transmission and reception it was not feasible to operate radio apparatus at high frequencies if any great amount of power was involved. So for many years the short-wave field slumbered on, waiting for those days beginning about 1923 when amateur experiments suddenly revealed that short wavelengths were not only useful for practical communication purposes but in many respects were far superior to the long waves previously employed in all commercial work. And, of course, when this was found to be the case, the commercial world immediately became interested in securing high-frequency (short-wave) assignments. Government stations, commercial land and ship stations, airplanes, police radio systems — these and many others, in addition to the pioneering amateurs, wanted their share. The result was that each type of service was assigned certain specific bands, and thereafter all operation by any particular service had to take place only in its own bands.

It may be interesting to you to know that the number, location and size of these bands are decided upon at radio conferences (some national and some international in scope) which direct how much of the high-frequency territory shall be given to each type of service. And it is in order at this point to mention that the ARRL is recognized both in this country and abroad as the official spokesman for the amateurs of America, and that it has had its representatives in active attendance and participation in every radio conference for thirty-five years on behalf of radio amateurs.

Now, getting back to these conferences: Since, when it comes to the high frequencies, there is a demand for more "channels" than there are channels available, the eventual assignments of territory represent a compromise mutually arrived at by the various interests.

The American amateur frequency bands are based upon allocations originally determined internationally at a conference held in 1927 at Washington, D. C., and for the most part continued right up to the present day even though many foreign countries at subsequent international conferences have tried to whittle down the frequencies available to amateurs — and, in the case of amateur bands in their own area, such as Europe, have succeeded. The FCC has always assigned amateurs in the United States the full width of every band available to the amateur service under international regulations. Let us see where these various channels are located.

The High Frequencies

Suppose we draw a long line to represent the territory above about 1600 kc. — the high frequencies. The major frequency bands assigned to amateurs, and an approximation of their widths, are shown in Fig. 1. All the spaces in between belong to other kinds of radio services. The figures are in *megacycles*, meaning millions of cycles or thousands of kilocycles; thus, in the middle of the column, 28.0 Mc. means the same as 28,000 kilocycles.

You may wonder why amateurs have several narrow bands instead of one single band equal to all the narrow ones put together. That is a perfectly good question and we will explain the reason briefly. Just as the high frequencies (short waves) behave differently from the lower frequencies (medium and long waves) so some of

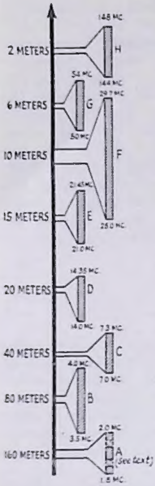


Fig. 1 — The major amateur bands. Additional higher-frequency bands are listed in the text.

the high frequencies exhibit characteristics different from others. The basic reason for the DX (distance) ability of all the high frequencies is the habit of most of the transmitted energy of shooting up into the air at an angle, then being bent by refraction in the ionized upper atmosphere and coming down to earth again. In traveling through the ionized region some of the energy of the wave is absorbed, and since this absorption is greatest for the lower frequencies, the higher-frequency waves can travel the longer distances, generally speaking. Thus, the comparatively low frequencies of 3500-4000 kc. work best, on the average, for moderate distances — up to one or two thousand miles, we might say. The amateur band *B*, therefore, is essentially a medium-distance band. Band *C* gives us satisfactory communication for greater distances, several thousand miles on the average and up to 10,000 miles under favorable conditions. Signals in band *D* will readily travel halfway around the world, as will those in bands *E* and *F* at certain times of the year and during certain years of the sunspot cycle. As we go upward in frequency, however, the bending in the upper atmosphere becomes less and less, and eventually a frequency is reached at which the bending is too small to bring the wave back to earth. Bands *G* and *H* are called very-high frequency bands; the sky wave is only occasionally useful on *G* and practically never on *H*. Communication on these bands and higher-frequency amateur channels, then, is ordinarily limited to only a few times the horizon distance (although under certain conditions in the ionosphere both bands *G* and *H* may furnish irregular longer-distance contacts). This very property, though, makes it possible to do short-distance work without much interference. Interesting experimental work is under way in these bands. Additional frequencies available to amateurs, not shown in the chart for lack of space, are:

26.96 — 27.23 Mc.
220 — 225 Mc.
420 — 450 Mc. (50 watts peak antenna power)
1215 — 1300 Mc.
2300 — 2450 Mc.
3300 — 3500 Mc.
5650 — 5925 Mc.
10,000 — 10,500 Mc.
21,000 — 22,000 Mc.

In addition, under a rather complex sharing arrangement with the loran navigational service, amateurs may use certain portions of the band 1800–2000 kc. If you are interested in such operation, write ARRL Headquarters for complete information on the latest governing regulations.

Learning the Code

In all probability the first thing you will do will be to start building a receiver. But at the same time you should also start learning the code. If you do this, by the time the receiver is completed you will have enough of a start that you can listen in and get code practice on the air while the transmitter is being assembled and while you are "boning up" for your license examination. Thus by the time your transmitter is completed and you are ready to apply for your license you will probably find that the practice you have had with your receiver will have fully qualified you for the code-speed requirement in the amateur operator examination.

Learning the code can be a lot of fun, and it's really easy if you approach it properly — that is, to think of it entirely in terms of sound. If you think of "dots and dashes" you're in for trouble. So go about it this way: When you see a • in the chart on the next page, call it a "dit" — say it to yourself and make it sharply and staccato. When you see a ▬ call it a "dahh" — accent it slightly and draw it out a bit, as "daahhhh." So the letter *A* would be pronounced "dit-dahh" — or, to make it sound more like the actual code letter when you hear it on the air, "didaahh." It should have the same accent and swing as "today," making the "to" very short and accenting "day." When speaking other letters, remember to keep the "dit" short, the "dahh" longer and accented. Yes, we said speaking — every time you see the code equivalent for a letter *say it to yourself*, and don't try to memorize a picture of it as printed. Practice saying strings of dits — dididididididi . . . etc.; it should sound like a blast from a machine gun. Then practice saying strings of dahhs — they should be long and smooth, with as short a space between them as your tongue can make.

The alphabet, numerals and punctuation marks are shown in this chart. Learn the letters in some random order such as E, T, A, R, I, S, N,

A	• —	dit-dahh
B	— • • •	dahh-dit-dit-dit
C	— • — •	dahh-dit-dahh-dit
D	— • •	dahh-dit-dit
E	•	dit
F	• • — •	dit-dit-dahh-dit
G	— — •	dahh-dahh-dit
H	• • • •	dit-dit-dit-dit
I	• •	dit-dit
J	• — — —	dit-dahh-dahh-dahh
K	— • —	dahh-dit-dahh
L	• — • •	dit-dahh-dit-dit
M	— —	dahh-dahh
N	— •	dahh-dit
O	— — —	dahh-dahh-dahh
P	• — — •	dit-dahh-dahh-dit
Q	— — • —	dahh-dahh-dit-dahh
R	• — •	dit-dahh-dit
S	• • •	dit-dit-dit
T	—	dahh
U	• • —	dit-dit-dahh
V	• • • —	dit-dit-dit-dahh
W	• — —	dit-dahh-dahh
X	— • • —	dahh-dit-dit-dahh
Y	— • — —	dahh-dit-dahh-dahh
Z	— — • •	dahh-dahh-dit-dit
1	• — — — —	dit-dahh-dahh-dahh-dahh
2	• • — — —	dit-dit-dahh-dahh-dahh
3	• • • — —	dit-dit-dit-dahh-dahh
4	• • • • —	dit-dit-dit-dit-dahh
5	• • • • •	dit-dit-dit-dit-dit
6	— • • • •	dahh-dit-dit-dit-dit
7	— — • • •	dahh-dahh-dit-dit-dit
8	— — — • •	dahh-dahh-dahh-dit-dit
9	— — — — •	dahh-dahh-dahh-dahh-dit
0	— — — — —	dahh-dahh-dahh-dahh-dahh

Period	• — • — • —
Comma	— — • • — —
Question mark	• • — — • •
Error	• • • • • • • •
Double dash (BT)	— • • • —
Wait (AS)	• — • • •
End of message (AR)	• — • — •
Invitation to transmit	— • —
End of work (SK)	• • • — • —

M, O, H, D, L, U, V, B, C, F, and then on to the remainder. By such a system you will soon be able to make up short words and even sentences out of the early letters, such as tare, start, rate, snore, etc.; practice saying these to yourself in didah language. As you progress, concentrate on the "harder" letters like Q, Z, J, etc., and then practice with the numerals and punctuation marks. Do not use the code chart for long study; pick out a few letters and learn them, and then lay this booklet away while you practice saying the sounds to yourself. Or hand the book to a friend so he or she can name some of the letters and check on your answers. When you are ready, go back to the chart to learn a couple more letters: again, lay the booklet away while you practice saying the new ones, mixing in plenty of the already-learned characters so you won't forget them. Don't hurry to read all the letters too soon. What you are doing is learning a type of mental coördination, and practice with only 8 or 10 letters is just as good from that standpoint as practice with all 26.

A very good way to develop code ability is for two people to learn the code together. Speak letters to each other, or simulate code by whistling or hissing through your teeth. Send single words, as soon as you know enough letters, while the other fellow writes down your "message." If you can find someone who will help you, the two of you should buy a buzzer and key, hook these up to a couple of dry cells, and send to each other. Figs. 2 and 3 show how a buzzer and key should be hooked up. By taking turn and turn about you can pick up code ability rapidly. Another good thing about this sort of practice is that it develops skill in sending, too, because the fellow who is receiving will be quick to criticize indistinct and uneven sending. When sending, sit comfortably at a table and make sure the key knob is far enough back so that your entire forearm can rest on the table. Grasp the knob lightly with your thumb and first two fingers; let the arm be relaxed as you work the key.

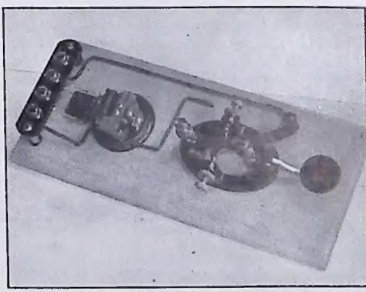


Fig. 2 — **A buzzer code-practice set.**

Additional helps on studying code are contained in *Learning the Radiotelegraph Code,* which you may obtain by sending 25¢ to the American Radio Relay League, West Hartford, Conn.

After a little practice along these lines, you should use your receiver to listen to actual signals being sent out by other amateurs. Most of them will be faster than you can copy, at first, but don't mind that. Every time you hear a letter that you recognize, write it down, even if it is only every

fifth or tenth letter. The point is to keep at it and make a real effort to copy every letter you possibly can. Don't be alarmed if you copy several consecutive letters and they don't make sense — many amateurs use abbreviations that will be unintelligible to you, at first. One common such abbreviation is CQ — general call of inquiry used by an amateur seeking a contact. You will hear many calls on the air such as CQ CQ CQ DE W1ABC W1ABC (or some other amateur call). Since these transmissions are usually repeated several times, they are some of the first things you will begin to read on the air.

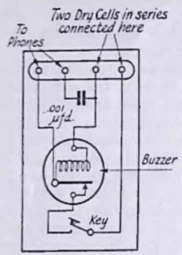


Fig. 3 — Circuit of the buzzer code-practice set shown in Fig. 2. The 'phones are connected across the coils of the buzzer with a condenser in series. The size of this condenser determines the strength of the signal in the 'phones. Should the value shown give an excessively loud signal, it may be reduced to 500 or even 250 μμfd.

It is very important that you know, rather soon in your code study, how perfectly-formed characters sound. Then you will have a standard after which you can pattern your own sending and "whistled" character formations. If you have access to a paper-tape code sending machine, of course, it is not only a good practice source but also fills the need for a standard. But the best means is to listen to W1AW, the Maxim Memorial headquarters station of the ARRL at Newington, Conn., which transmits bulletins and code practice in the evenings using an automatic keying device. Transmissions are made simultaneously on 1885, 3555, 7130, 14,100, 21,020, 52,000 and 146,000 kilocycles. If you reside within a few hundred miles of Connecticut, the 1885- or 3555-kc. frequencies will probably serve you best; at greater distances, 7130 and 14,100 kc. will be more useful. Code practice begins at 9:30 P.M. EST. On Sunday-Tuesday-Thursday-Saturday there is ten minutes of practice at each of the following speeds in succession: 5, 7, 10 and 13 words per minute; these will be the best evenings for lower-speed practice. On Monday-Wednesday-Friday the speeds are 15, 20, 25, 30 and 35 w.p.m. The text of practice material is taken from *QST* articles, so if you obtain *QST* regularly you will have a means of checking the accuracy of your copy. In addition, W1AW transmits bulletins of general information to amateurs on the same frequencies at 8 P.M. EST each Sunday through Friday, and again at midnight EST each Monday through Saturday; when you build up a little speed you can use these bulletins for additional practice, since they are sent at 18 w.p.m. (Times change to EDST during the summer months.)

It is probably safe to say that the majority of the amateurs on the air today found listening on their receivers one of the best means of learning code. So keep at it — try to get in a few minutes every day, rather than a full hour or two only once a week. Before you know it, you will be copying solid sentences.

When you can consistently copy 13 words (65 letters) a minute, you are sufficiently well equipped on this score to pass the government code-speed requirement in connection with your General or Conditional Class amateur operator license. For a Novice or Technician Class license, you need only pass a code test at 5 w.p.m. (See the later section in this booklet on "Licenses".) It is a good thing, of course, to learn to copy a little faster than 13 (or 5) words a minute before you take your license examination, because if you are like most amateurs you will get just a little rattled when you actually go to take your test, and it is wiser to be on the "far" side of the requirement than on the "near"! Concentrate on the less frequently used words and characters, too.

How Radio Works

The radio amateur must have a reasonably good general knowledge of radio principles, not only to build and operate his equipment successfully but to pass the Federal license examination. This does not mean that an engineering training in the subject is required; it does mean, however, that some time and application in acquiring an understanding of basic principles will be required.

The study of a standard radio text is recommended.* The brief explanations which follow are intended to serve only as a preliminary to such study, particularly for the benefit of those without previous knowledge of radio or electricity.

You have heard of *molecules*, as the smallest units to which any substance — wood, metal, water — can be broken down. These molecules are made of up various combinations of *atoms*, which are the basic chemical elements. Every substance known is made up of various combinations of these atoms of which there are more than 90 varieties.

When we try to go inside the atom, in order to

* When you first start studying, the various terms and ideas may well seem very strange and complex. But, as you plug away at it you will soon find that it all makes sense. Above all, don't get discouraged. Have patience — and perseverance.

learn what it is made of, we leave the field of solid *physical* matter and must think in terms of *force.* For atoms are made up of *electrons*, and electrons, as you might guess from their name, are nothing more or less than electrical charges — little bits or particles of energy or force. Each atom contains a number of these electrons, together with a *nucleus;* the electrons are believed to rotate about the nucleus much like the planets about the sun. The nucleus, in turn, is made up largely of *protons* and *neutrons.* The protons are the opposite of electrons; they have a *positive* charge, while the electrons have a *negative* charge. There is also a large difference in the mass of the two — the proton being about 1860 times heavier than the electron. The neutron has the same mass as the proton but has no charge.

The Electric Current

You know that when two permanent magnets are placed together with the north and south poles facing they exert a mutual attraction. Similarly, the positively-charged nucleus attracts the negatively-charged electrons; in many substances the attraction is so great that the electrons are rigidly held and can escape only with great difficulty. In other substances, however, the electrons are not so strongly attracted, and it is quite easy to dislodge them. If an electron is dislodged from an atom in such a substance, this atom in turn attracts a new electron from a neighbor, and the neighbor from its neighbor down the line, and so a regular chain of motion is set up. This motion of the electrons is called *electric current,* and it is the basis of all electricity and all radio theory.

The careful reader will have noticed that only in some substances was it said that this movement of electrons is easy. Such substances are known as *conductors*, because they conduct electric currents quite readily. They include most of the metals, especially silver, copper, aluminum and steel (listed in the order of their *conductivity*).

Other substances have electrons so firmly fixed in their atoms that they are dislodged only with great difficulty, and little or no electric current can flow. Such materials are known as *dielectrics* or *insulators*, meaning that they can be used to insulate electric currents when placed between the conductors of those currents. Bakelite, porcelain and other ceramics, wood, rubber, air — these are good insulators.

Resistance

This characteristic of nonconductivity is described as *resistance* — actually, the resistance of the electrons to being dislodged from the atoms. Certain metals have a relatively high resistance; a small amount of current can be made to flow in some nonmetals, on the other hand, and they are therefore not regarded as good insulators.

In trying to force movement of electrons, or current flow, in poorly conductive wire the energy used to overcome the resistance of the wire is dissipated or used up in the form of heat. Examples of this are such electric appliances as toasters, stoves, etc., where the heat generated by forcing electricity through high-resistance wire is put to use. In the case of an electric light bulb, on the other hand, not only is heat generated but the wire glows from the heat, like a piece of red-hot metal in a fire, and thus creates light.

The measure of the resistance in any given piece of wire is stated in *ohms.* This is a term derived from the name of the man who first found that the resistance of a piece of wire was constant regardless of the amount of current flowing through it, and who, on this fact, established what is known as *Ohm's Law.* This is the basic law in electricity. It states that *one ohm is the resistance through which one ampere of current will pass at a pressure of one volt.* From the way the statement is made it should be easy to guess that an *ampere* is the measure of the quantity or amount of electric current (like gallons of water per minute), while the *volt* is the measure of pressure.

Remember this expression of Ohm's Law. You will use it innumerable times in your radio career. Expressed as a formula, using the standard symbols of I for current, E for volts, and R for resistance, it reads:

$$I = \frac{E}{R}$$

A.C. and D.C.

So far we have considered only one kind of electric current — *direct current*, or *d.c.*, flowing continuously in one direction: from negative to positive.

There is another kind of current, known as *alternating current*, or *a.c.*, in which the direction of the current reverses periodically. At one instant this current flows in one direction, at another instant in the opposite direction. Each such complete set of changes is called a *cycle.* The rate at which these changes occur is known as the *frequency* of the current. The polarity of ordinary house-lighting current reverses 120 times each second; its frequency is, therefore, 60 cycles per second.

Alternating current obeys laws similar to those of direct current. It is measured in amperes and volts. Although the actual current and voltage at any instant may vary from zero to maximum, the *effective* values approximate the values for d.c. supplying equivalent power. These effective values are considered to be approximately 0.7 times the maximum, or *peak,* values.

Inductance

In the case of d.c., the flow of current is limited only by the resistance of the conductor. With a.c., however, the problem becomes more complicated. First of all, let us consider *electromagnetism.* When a current flows through a coil of wire, lines of magnetic force, similar to those in a permanent magnet, are set up by each turn of wire. All of these lines of force together are called the *magnetic field.* However, we are not so much interested in the magnetic qualities of the coil as in their effect on the coil itself.

The lines of force created by each turn of wire also cut across other turns in the coil. In doing so they transfer energy to these other turns, setting up additional current; this is called *induced* current. The induced current flows in the opposite direction to the original current, building up a back pressure opposing the current flow. The more turns in the coil, the greater this induced current — the greater the *inductance* of the coil. It happens that coils are measured by their inductance; the unit of measurement is the *henry*, commonly reduced to millihenrys or mh. (thousandths of a henry) and microhenrys or μh. (millionths).

In the case of d.c., the induced current exists for only a brief moment while the magnetic field is building up; thereafter, the current flow is limited only by the resistance of the wire. With a.c., however, the magnetic field builds up and collapses with each alternation. This sets up an intermittent retarding action which serves to limit the flow of a.c. by the average net value of the induced current. In other words, still more resistance to current flow, in addition to the resistance of the wire, has been introduced; this special kind of resistance is called *reactance*. It affects only a.c. It is measured in ohms. The greater the inductance of a coil the higher the reactance — *inductive reactance*, that is, because it is an effect of the inductance of the coil. Inductive reactance increases in direct proportion to the frequency of the current, in contrast to inductance, which does not change with frequency.

Now, having shown what happens in one coil, suppose we put two coils side by side. If current is passed in one, the magnetic field set up in it also cuts across the other. Induced current is set up in the second coil, as well. If suitable conditions exist, practically all the power in the first coil can be transferred to the second — the voltage and current relationships being in ratio to the number of turns in each coil. This *coupling* or transfer of power is called *transformer* action.

Capacitance

Although a.c. cannot flow through a coil as readily as does d.c., it can apparently flow through an insulator where d.c. cannot. If two conducting plates are placed adjacent with an insulator between them and current is generated or set in motion along a wire connecting the two plates, electrons will pile up on the "negative" plate. This will continue until the pressure of the piled-up electrons equals the voltage pressure from the current generating source. The condenser is then said to have an *electrostatic charge;* the extent of the charge, or the number of electrons which can be accumulated on the plate before a given voltage is reached, is determined by the *capacitance* of the condenser. Like the inductance of a coil, it does not change with frequency. Capacitance is measured in *farads;* this unit is so large that microfarads or μfd. (millionths of farads) and even micromicrofarads ($\mu\mu$fd.) are customarily used.

So far, in considering capacitance, only the effect of d.c. in charging the condenser has been shown. With a.c., the reversal of polarity causes the charge to build up and collapse with the frequency of the current. This rapidly-changing charging current is actually the equivalent of an alternating current through the condenser. Of course, condensers do not permit alternating currents to flow through them with perfect ease. They impede an alternating current just as an inductance does. This effect is known as *capacitive reactance*, and it is the opposite of inductive reactance. It decreases with an increase in frequency, being *inversely proportional* to frequency and capacitance.

Resonance and Tuning

We come now to a very interesting phase of the subject—*resonance*. It is resonance which enables *tuning* — the ability to select only one radio station from all those on the air.

It was said that reactance changes with frequency — inductive reactance going up in value, capacitive reactance down, with increased frequency. With a given value of capacitance, therefore, there is only one value of inductance that will have the same value of reactance as the condenser at a given frequency. Now it happens that the two kinds of reactance are opposite in their effect upon current flow. If a coil and a condenser of equal reactance are connected in series with an alternating-current source, therefore, the two reactances, being opposite in their effect, cancel out — and the only resistance limiting current flow is that of the wire.

This is true at only one frequency, however, since the reactances change with frequency and in opposite directions. Thus that particular coil-and-condenser combination is *resonant* — a *tuned circuit* — at that one frequency. If the frequency is changed the current flow is again limited by the reactance, and the circuit will therefore discriminate against all other frequencies. The "sharpness of resonance" — the degree of selection between the resonant frequency and adjacent frequencies — depends largely on the ratio of the reactance to the a.c. resistance of the coil.

All of the electrical principles discussed so far are involved in the operation of radio equipment.

There is, first of all, the identification of "radio" with "alternating current." The a.c. used as an example in explaining electrical theory had a frequency of 60 cycles per second — ordinary commercial house-lighting current. In some localities a frequency of 25 cycles is used for such current. Getting away from power, if we change sound waves in the audible range into electrical pulses we have a.c. ranging from perhaps 20 to 16,000 c.p.s.

Radiation

At about this point (16,000 c.p.s.) it no longer becomes necessary to send current over a wire; instead, it can be sent through space in the form of *electromagnetic radiation*. Just what this is and how it works no one fully knows. It is sometimes explained as vibrations in a mythical substance called the "ether," akin to sound waves in air.

You might like to think of it as an enormous magnetic field.

Anyway, if a piece of wire — an antenna — is supplied with a.c. power of sufficiently high frequency, it will radiate that energy into space. It will travel at a rate of something like 186,000 miles per second until it has all been dissipated. It is convenient to visualize this energy as traveling in waves, and since the velocity can be assumed constant, the "wavelength" is the reciprocal of the frequency. In other words, radiated *radio-frequency* or *r.f.* energy (as it is termed to distinguish it from ordinary a.c. in wires) of 1,000,000 cycles per second (ordinarily described as 1000 *kilocycles* or kc., *kilo* meaning thousand) will have a wavelength of 300 meters (it being the habit to describe wavelengths in meters rather than feet). This is found by dividing 1,000,000 into 300,000,000 (the latter figure being the velocity in meters per second equivalent to 186,000 miles per second).

The energy thus sent forth will, generally speaking, radiate in all directions from a simple antenna wire. Some of it will go along the ground, until it is dissipated, intercepting all receiving antennas in its path and inducing small bits of energy in each. This is the *ground wave*. Most of it will go off into space. This is the *sky wave*. With short wavelengths, this r.f. energy is often *reflected* by an ionized layer of air in the upper atmosphere called the *ionosphere*. It thus comes back to earth at great distances, affording the extraordinary ability of the short waves to cover the world with little power.

We turn now to the methods of generating and receiving this r.f. energy we have been talking about.

Vacuum Tubes

The heart of all modern radio-frequency generating and receiving systems is the *vacuum tube*.

We have previously discussed the effect of passing an electric current through the wire, or *filament*, in an ordinary light bulb; the resistance or friction of the wire causes it to *incandesce*, generating heat and light. It also does something more. When the filament is sufficiently heated the electrons not only vibrate furiously in the wire but even leave it. They then cluster around the outside in what is known as a *space charge*.

Now if a *plate* of metal which is given a positive charge from a battery or other electrical source is placed in the evacuated bulb, the electrons in the space charge will stream toward this plate, the vacuum offering little resistance to their flow. This flow is actually an electric current — more specifically referred to as an *electronic* current because it is not in a wire — but it will flow only in one direction: from filament to plate. If a.c. is placed on the plate, therefore, current will flow only during that half of the cycle when the plate is positive. This is called *rectification* — the process of changing a.c. into pulsating d.c. by means of a rectifier tube.

This characteristic of rectification may be used in several ways in radio work. First of all, it may be used to change the 60-cycle a.c. from the power lines into d.c. The d.c. that comes from the rectifier tube will be pulsating, rising and falling with each cycle, but it can be smoothed out by running it through a *filter* — a combination of inductance and capacitance which levels off the hills and fills in the valleys.

Detection

Detection is the most important use of this rectification characteristic. It is also called *demodulation*. It consists of taking the r.f. signal that comes in over the receiving antenna and changing it into either the audible dots and dashes of the telegraph code, the audio frequencies of the human voice, the multitudinous pulses of a television picture, etc.

Thus far we have been talking of a vacuum tube with only two elements or *electrodes*, plate and cathode. (The cathode is the filament in certain tubes; in others it is a metal sleeve coated with electron-emitting material which is indirectly heated by the filament.) This type is called a *diode*. There are other types which not only rectify but *amplify*, as well.

These more complex types include an additional element or electrode called a *grid*. It consists of a mesh of fine wires placed between the cathode and plate. In effect, the grid is a valve, controlling the flow of electrons. If it is given a positive charge, it accelerates the flow and more electrons go to the plate — the *plate current* increases. If the grid is given a negative charge, however, this discourages the electron flow and limits the plate current. If it is sufficiently negative practically all current flow is stopped; this is called *cut-off*.

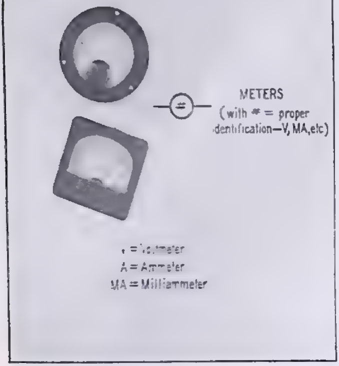
Amplification

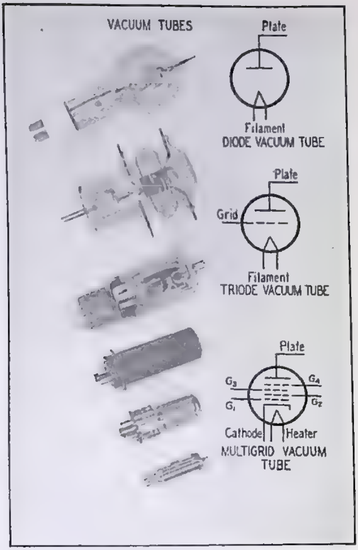
Now, suppose we have a positive d.c. voltage on the plate of a tube. This causes a continuous d.c. flow. Then, suppose we put a negative d.c. voltage on the grid. A certain value of grid voltage will serve to cancel the influence of positive plate voltage, causing cut-off. Since the grid is nearest the filament, the voltage required on it will be smaller than that on the plate. The ratio between the grid and plate voltages required to produce the same effect on the plate current is called the *amplification factor*.

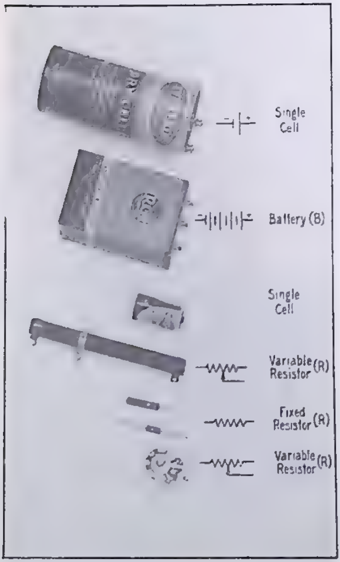
Suppose, further, that instead of having d.c. on the grid we have a.c. As the grid voltage changes through each cycle the plate current changes simultaneously. Now, if the plate current is taken through a resistance or a reactance, this plate-current variation will set up a corresponding a.c. voltage — a voltage greater than the grid voltage by the amplification factor of the tube. Thus, where we have an a.c. grid voltage of perhaps 1 volt, we end up with a corresponding a.c. voltage in the plate circuit of perhaps 10 volts. The signal has been amplified 10 times. This may be done either at r.f. — before detection — or at a.f., after.

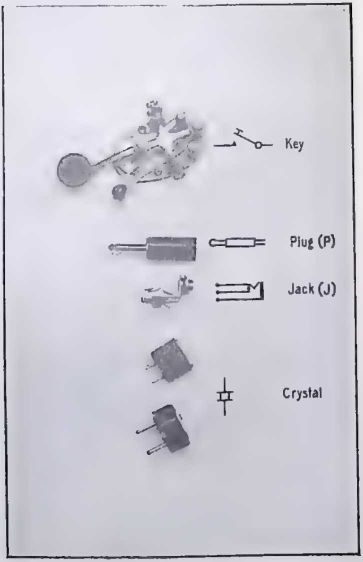
It is by this means that the microscopic power

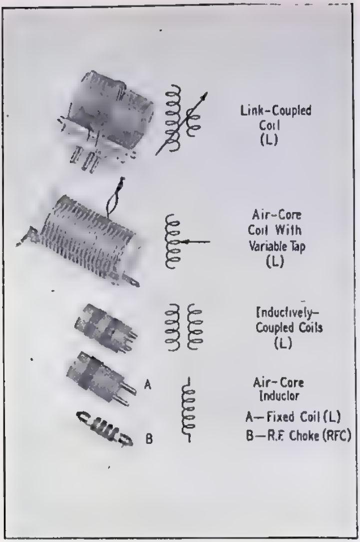
Schematic Diagrams of Common Radio Parts Together with Pictorial Examples for Ready Association.

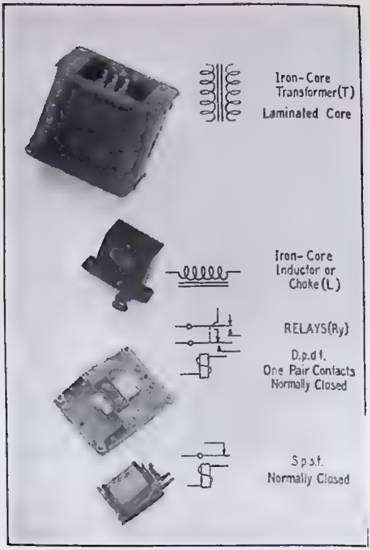


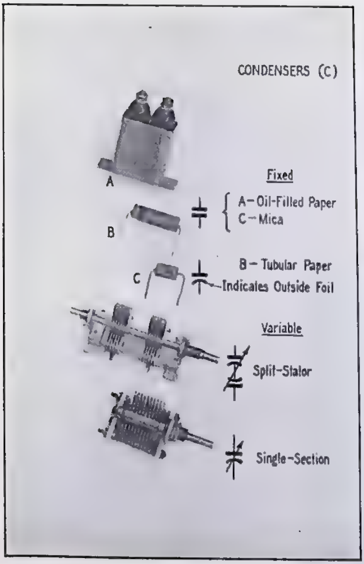


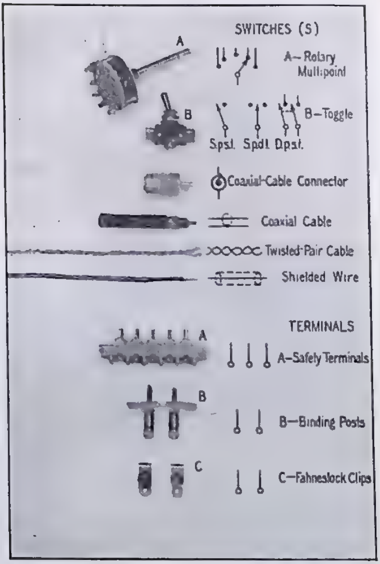





Link-Coupled Coil (L)
Air-Core Coil With Variable Tap (L)
Inductively-Coupled Coils (L)
A
Air-Core Inductor
A—Fixed Coil (L)
B
B—R.F. Choke (RFC)


Iron-Core Transformer(T)
Laminated Core
Iron-Core Inductor or Choke (L)
RELAYS(Ry)
D.p.d.t.
One Pair Contacts Normally Closed
S.p.s.t.
Normally Closed


CONDENSERS (C)
A
Fixed
B
A—Oil-Filled Paper
C—Mica
C
B—Tubular Paper
Indicates Outside Foil
Variable
Split-Stator
Single-Section


SWITCHES (S)
A
A—Rotary Multipoint
B
B—Toggle
Spst. Spdt. Dpst.
Coaxial-Cable Connector
Coaxial Cable
Twisted-Pair Cable
Shielded Wire
TERMINALS
A
A—Safety Terminals
B
B—Binding Posts
C
C—Fahnestock Clips

of a radio signal in a receiving antenna — less than a billionth of a watt — can be built up to the 5 watts or more of power delivered to the average loudspeaker.

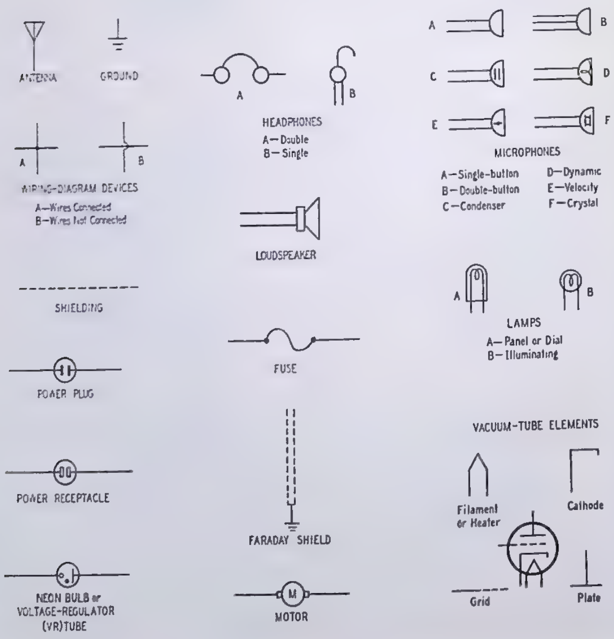
A tube having three elements — cathode, grid, plate — is called a *triode*. There are tubes called *tetrodes* in which a *screen grid* (sometimes called an accelerator grid) is inserted between grid and plate as an electrostatic screen. This greatly increases the amplification factor. *Beam* tubes also have four elements, in which the fourth electrode is used to concentrate the electron flow to the plate for maximum efficiency. *Pentodes* are tetrodes with still another grid, located between screen and plate. This third grid is called the *suppressor grid;* operated at cathode potential, or voltage, it further improves tube performance by preventing electrons from bouncing back to the earlier grids from the plate.

Oscillation

The generation of radio-frequency power is also accomplished by the vacuum tube, and it also utilizes this characteristic of amplification. Suppose that in the amplifier discussed above 1/10 of the 10 volts in the plate circuit is put back into the grid circuit — *feed-back,* it is called. This is the same as though the tube were supplying its own input signal, and, once started off, the tube will continue in this way indefinitely. This is called *oscillation.*

To start oscillation in a tube fitted with a feed-back circuit, it is customary to include a *grid leak* and *grid condenser* in the circuit. When plate voltage is applied, the grid, being in the electron stream, collects a few of the electrons going to the plate. This charge is applied to the condenser, which then dissipates its charge through the leak resistance. The pulsing grid voltage thus resulting is enough of an input signal to start the tube oscillating; given this start, it keeps going by itself.

So we see how the vacuum tube is used in the various circuits of a radio system. First, it converts the commercial a.c. power into d.c. for plate voltage. Second, it is used as an oscillator to generate r.f. power (and also as a power amplifier to increase that power in the larger transmitters). Third, it is used as a detector to convert the r.f. signal into intelligence. Finally, it is employed to amplify the weak signals into usable quantities.



Schematic symbols used in circuit diagrams

A Simple Receiver

Should you build your own receiver and transmitter, or should you buy one of the manufactured units now available? Every beginning amateur has faced that question. Despite the possible temptation to buy ready-made equipment, we strongly urge that you build at least your first transmitter and receiver — even though you can afford to buy the best on the market.

Parts List for the Regenerative Receiver

C_1, C_2 — 100-μμfd. midget variable condenser (Millen 20100 or Bud MC1855)
C_3 — 100-μμfd. fixed condenser (Erie Ceramicon)
C_4 — Two wires twisted together (see text)
R_1 — 15-megohm resistor, ½ watt
Aluminum chassis — 5" x 7" x 2"
Aluminum panel — 6" x 7" (obtainable at any sheet metal shop)
Vernier dial (National BM)
Regeneration control knob
Tube socket — 7-prong miniature bakelite
Coil socket — 4 prong bakelite
Coil forms — 1" diameter, 4-prong base (Millen 45004 or National XR-1)
Radio tube — Type 3S4
'Phone-tip jacks, insulated type
Headphones, 2000-ohm (such as Trimm "Dependable")
Filament batteries (2 flashlight cells in series, 3 volts)
B battery, 22½ volts (Eveready No. 768)
Hook-up wire, 25-foot roll
⅜" rubber grommets, ¼" hole (8 needed)
Miscellaneous 6-32 and 4-36 machine screws and nuts
¼-lb. roll No. 26 enamel-covered magnet wire
Several soldering lugs
Package of metal spacers (to support coil socket)
If receiver is modified for bandspreading, per text, also a 20 μμfd. midget variable condenser (Millen 20920 or Bud MC1850) and a knob for same.

Only by actually building and testing radio apparatus can you acquire the thorough understanding of radio that every good radio amateur should have. All the theory in the world cannot take the place of practical experience — and the only way to gain experience is to do the thing yourself. So build your own, at least at the start.

The little one-tube regenerative receiver that we are about to describe is just about as simple and inexpensive as it is possible to make. You may not want to use it as a permanent receiver for your amateur station — although it's perfectly useful for that purpose early in your amateur career — because since it has a minimum of parts it does not have very high performance. Its main function is to give you a little practice in the building of equipment, in the use of simple tools and a soldering iron, and further practical experience on how radio works — and at the same time ending up with a unit on which you can hear amateur and commercial signals and get a good idea of what goes on in the radio spectrum. Based on price lists of any of the amateur radio supply houses, this one-tube receiver will cost a little less than $15, complete with headphones and battery power supply. If you already have a few radio parts, or have a friend with a "junk box," chances are that you can find at least some of the necessary items that way, especially the miscellaneous hardware.

Because the mechanical construction and the electrical wiring are so simple, it's not necessary to go into lengthy description on how to build the receiver. The photographs show you quite clearly the layout of the parts, and in addition you can refer to the two scaled-down templates (layout patterns) for guidance in locating the various holes which must be drilled. No expensive array of tools is needed. You should have, or have access to, a soldering iron, some rosin-core solder, a screwdriver, a pair of pliers (preferably needle-nose side cutters), a hack saw, a jackknife, a ⅛-inch and a ¼-inch drill, and a hand drill for them. The ⅛- and ¼-inch drills will take care of most of the holes you need to drill in the chassis and panel, but the holes for the variable-condenser shafts, the 'phone tip jacks and the tube socket will have to be enlarged. If you have a friend with the necessary tools (larger drills),

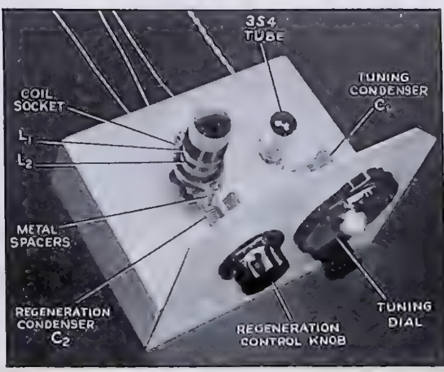
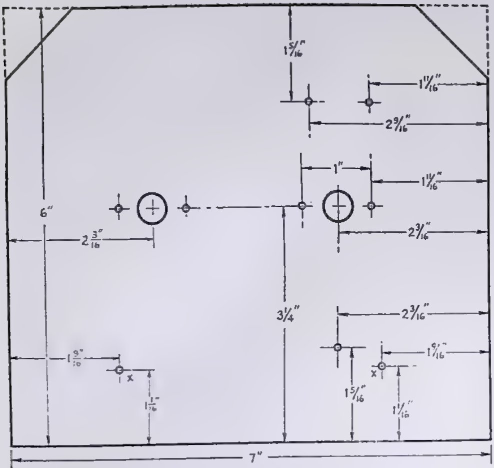


Fig. 4 — The completed one-tube regenerative receiver, ready to operate.



PANEL TEMPLATE

Fig. 5 — Panel template, with dimensions for drilling the necessary holes. If Bud condensers are used, the two small holes each side of the larger holes will not be necessary.

this can be done easily; otherwise, with a little patience you can ream them out yourself with the knife, since the aluminum is quite easily worked.

The first step is to lay out the aluminum chassis and panel in accordance with the measurements in Figs. 5 and 7. Although it isn't necessary, in the model shown we beveled off the top corners of the panel, both to improve appearance and to keep from inadvertently cutting one's hand on the sharp corners; you can do the same with a hack saw or a borrowed tinsnips, or you can borrow a file and simply round off the sharp corners. Mark the centers of the various holes, using the dimensions shown on the templates, as carefully as possible, and drill them. The two holes marked "X" on the panel template of course must be drilled also through the front of the chassis; you can use the holes in the panel as a guide. Then mount the panel on the chassis with bolts and nuts. Force rubber grommets into the four holes where the coil socket will be mounted, and into the four holes along the rear of the chassis; these are to prevent wires from shorting to the chassis.

Using the metal sleeves (spacers) and long bolts, mount the coil socket as shown in the photographs, with the two larger pin holes toward the rear of the chassis. Now add the tuning condenser (C_1) and the regeneration control condenser (C_2). These have long shafts, which may need to be cut off with the hack saw so that the tuning knobs will not stick out too far from the panel. Next comes the tube socket, for which you must use the smaller 4–36 bolts; assemble this with the blank space between Pins 1 and 7 (marked on the socket) toward the right front corner of the chassis Then come the 'phone-tip jacks; be careful about the special washer that comes with them, so that you keep the metal threads on the sleeves away from the aluminum chassis, again to prevent shorting. Now, using the hole 1¼ inch from the front of the chassis, bolt one soldering lug to the top of the chassis and another on the bottom, both on the same bolt; this is to furnish a common "ground" point on the chassis, since radio frequencies sometimes act up unless all common ground connections are made to the same chassis point. After you have mounted the two dials, you are just about finished with the assembly,

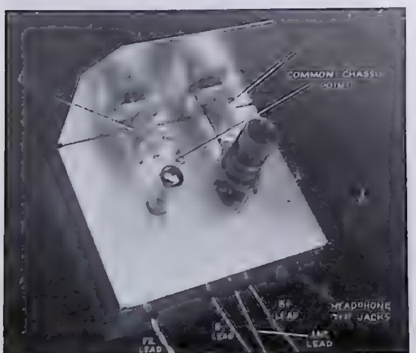


Fig. 6 — A rear view of the receiver, showing the placement of parts above the chassis.

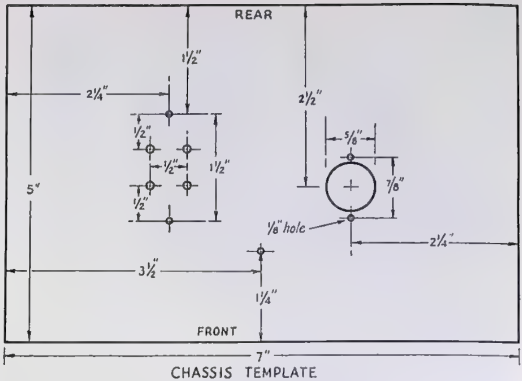


Fig. 7 — Chassis template, with dimensions for drilling the necessary holes. Two additional holes are necessary in the front side of the chassis, to match those marked *X* in Fig. 5.

but it is a good idea to double-check and make sure all bolts and nuts are tight. It has probably taken you a couple of hours to get this far along with the construction, so now would be a good time to sit back and relax and study the diagram of wired connections, Fig. 9, while we explain very briefly how the receiver works.

In previous paragraphs we talked about reactance and tuning. Take a few minutes now to review the previous section on "How Radio Works," particularly *Resonance and Tuning, Vacuum Tubes, Detection,* and *Oscillation.* In this receiver, C_1 is the tuning condenser, by means of

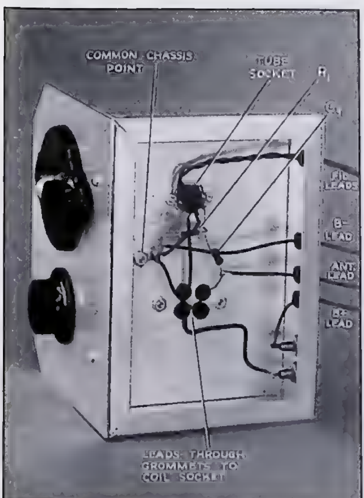


Fig. 8 — A view under the chassis, showing the simple wiring.

which you select the frequency at which the coil (L_1) and condenser are resonant — in other words, the frequency you want to listen on. This is a *regenerative* receiver, which means that some of the energy in the plate circuit is fed back to the grid to be amplified again and again. This is

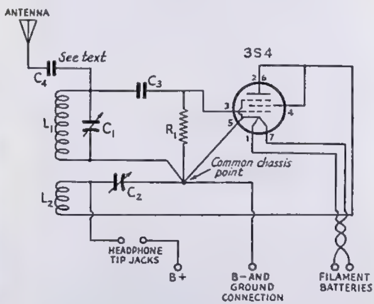


Fig. 9 — A schematic diagram of the wiring of the simple regenerative receiver.

accomplished by coil winding L_2. Variable condenser C_2 controls the amount of *feed-back.* As its shaft is turned to mesh the plates more and more, a point will be reached at which the receiver will break into oscillation; if you turn it rapidly when the receiver is wired and operating, you will hear a little "plop" as the receiver starts to regenerate. More on this later; first, let's wire the unit.

The diagram of the receiver circuit in Fig. 9 is known as a schematic diagram. Refer to the photographs on pages 10 and 11 of this booklet for an explanation of the various symbols In Fig. 10 you will see that there are several elements in the tube, and each one is connected to a pin on the base of the tube. (In such texts as *The Radio Amateur's Handbook* you will find whole pages of charts of the various tubes and their

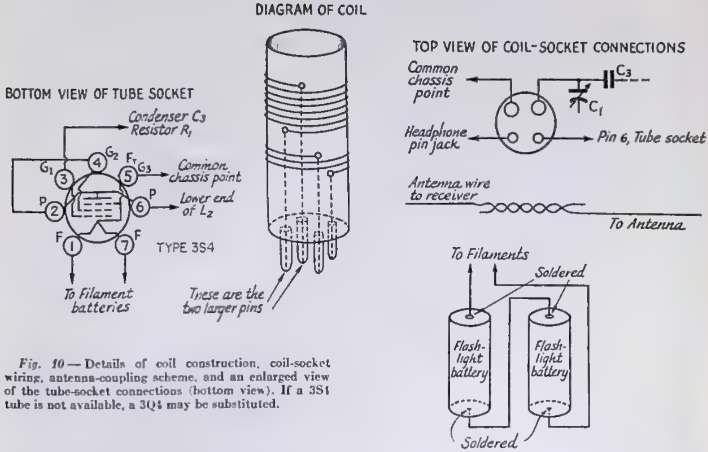


Fig. 10 — Details of coil construction, coil-socket wiring, antenna-coupling scheme, and an enlarged view of the tube-socket connections (bottom view). If a 3S4 tube is not available, a 3Q4 may be substituted.

socket connections.) Reference to the socket diagram of the Type 3S4 tube in Fig. 10 will show you what wires should be connected to the various terminals. If you have laid out the chassis in accordance with the photograph, you will find that the wires fit into place quite neatly. Proper layout is something you will want to consider in each piece of equipment you construct, so that the parts will be neatly arranged and the connections as short as possible.

Now, armed with your soldering iron, solder, hook-up wire and pliers, you are all set to commence wiring. This is a simple job, because there are so few connections to make. Just be sure you don't slip when it comes to making the connections to the terminals on the tube socket, and be sure again that you get the connections to the coil socket correct. Note that the diagram of the tube socket is a bottom view of it while, for convenience, the view of the coil socket is a top view. Use care in soldering to get good electrical connections. Before soldering, make sure the two wires or pieces of metal are clean; heat them thoroughly with the tip of the iron, and then touch the end of the solder to the joint. You will be surprised how little solder is necessary. Keep the joint hot for a moment, to burn off any excess rosin. Withdraw the iron carefully and hold the wire in position another couple of moments to insure hardening without disturbing the solder.

The wires to the batteries, coming out the back of the receiver through those rubber grommets, should be made long enough to permit easy connection to the battery terminals. The antenna wire should be only 6 or 8 inches long, for use as we shall explain later. To avoid any confusion, you might find it a good idea to take some small pieces of paper and Scotch Tape and make labels for each wire, so that they will be clearly and permanently identified.

The final step is to wind the coil. Refer to Fig. 10 and the coil table carefully. The windings must bear the same physical and electrical arrangement to each other as shown in the diagram. The turns of each winding are "close-wound" — that is, without spacing — but keep the two windings exactly the distance apart shown. You will find this construction job a little tricky, but if you use reasonable care you'll make out all right. Fasten the wires in the coil-form pins by scraping the enamel insulation from the wires, extending the wires through the holes in the pins, and running some melted solder into the holes; then snip off the excess wire flush with the end of the pin. Be sure to get a good electrical and mechanical connection here by using plenty of heat from the soldering iron. Then, wipe the coil-form pins carefully to make sure any residue of rosin is removed.

Coil Table for the Regenerative Receiver

	L_1	L_2	*Spacing Between Two Windings*
Coil A	25 turns	7 turns	¼ inch
Coil B	9 turns	4 turns	⅜ inch

Using the Receiver

Now you're ready to give the receiver a whirl. Probably you already have some sort of antenna up; if not, you can use twenty or forty feet of hook-up or other wire strung around the room, although a longer outdoor antenna will give much better results. Make your first test in the evening, since more stations are active and sig-

nals are usually much stronger then. Take the end of your antenna and the 6-inch stub of insulated wire coming from the receiver, and twist them together three or four turns; this in effect is a small condenser, and gives you capacitive coupling between your condenser and antenna — the more turns of the two wires around each other, the greater the coupling, and this is something you will want to experiment with since every antenna installation is different. But don't connect the metal wire of your antenna to the metal wire of the antenna receiver lead; leave the insulation on both wires and just twist the two without exposing the metal (see Fig. 10).

Insert Coil *A*, and plug your 'phones in the tip jacks. Connect the filament wires to the two flashlight batteries as shown, and the B battery as shown; make sure these connections are tight, or the receiver will be noisy. You might find it helpful to run a wire between the B-negative post of the battery and a good ground connection, such as a radiator or water pipe. Now, rotate the regeneration condenser knob; if you listen carefully you should hear that "plop" we spoke of earlier. Another test for regeneration is to leave the condenser plates full meshed and then touch the stator (fixed plates) of the *tuning* condenser with your fingertip; you should hear a click in the 'phones when you do. If not, it means there is no regeneration, so check to see whether you have all the connections to the coil socket and other parts of the receiver correctly made. As a last resort, add a couple of turns to "tickler" coil L_2. (You probably won't have any trouble, but these are some of the remedies if you do.)

Unless you are a very unusual type of person it is probable that you will have your receiver hooked up to the antenna and "on the air" within a very few minutes after you have soldered the last connection and tested the set for satisfactory operation. And it is probable, too, that all other activity will be suspended for a number of days thereafter, while you learn to tune the set to best advantage, find out where the amateur bands are, and generally have a good time exploring the new world that opens up to those who venture forth into high-frequency reception.

Listening-in on the high frequencies is a revelation to people who up to that time have thought that most radio transmission and reception is confined to broadcasting. A horde of radio signals from dozens of different types of services tell their story hourly to whomever will listen. Some stations send slowly and leisurely, and even the beginner can read them. Others race along furiously so that whole sentences become meaningless buzzes. There are both telegraph and telephone signals: press messages, weather reports, time signals, transocean commercial radiotelephone and telegraph messages, international broadcasting of voice and music, transmissions from government and experimental stations, airplane dispatching, police broadcasts, signals from private yachts and expeditions exploring the uttermost parts of the earth — signals jam the high-frequency spectrum from one end to the other. And sandwiched in among all these services are the amateurs, hundreds of whose stations may be heard every night.

You will soon become familiar not only with the location of the various amateur bands but with the fact that there is quite a bit of difference in the type of work carried on in each band. Coil A enables you to tune from about 3500 kilocycles to about 7500 kilocycles, thus covering both the 80- and 40-meter amateur bands as well as the space in between. As you rotate the tuning dial slowly, you will hear various kinds of signals. With the tuning condenser plates set so

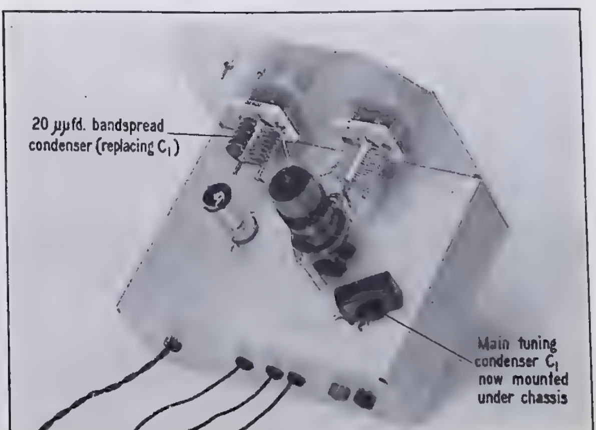


Fig. 11 — The "improved" model, showing the bandspread condenser replacing the main tuning condenser, which has been moved under the chassis near the coil.

that they are almost completely meshed (full capacitance), the receiver tuning will be in the vicinity of 3500 kc. The 80- meter amateur band extends from 3500 to 4000 kc. On the lower portion of this band you will find c.w. (code) stations, and to receive them you want the regeneration control in the oscillating position so you get a whistle or *beat note*. Above 3750 or 3800 kc. and up to 4000 kc. you will hear amateur voice or 'phone stations; to receive these, the regeneration condenser should be unmeshed just enough to take the receiver out of oscillation. From 4000 to 7000 kc., that is, through most of the center section of the tuning dial, you will find various types of commercial stations. In the United States, only amateur code stations may operate in the lower portion of the 40-meter band (7000 to 7300 kc.) while voice operation is permitted above 7200 kc. Other countries have different regulations, and so you may hear foreign short-wave broadcast stations. Later, you will probably want to wind Coil B and look for the 20-meter amateur band plus other signals in that portion of the spectrum, upwards of 7000 kc.

Soon you will have a pretty good idea of the performance of the receiver. You will find that it "blocks" or overloads with extremely strong signals (such as those of an amateur living nearby), and that sometimes it is hard to separate stations in crowded bands, since it is not too selective. However, it is a perfectly useful receiver for an amateur station, as we have demonstrated by using this very unit, plus the little transmitter to be described in the next section, in an amateur station — and very successfully, too.

If you decide to use this receiver extensively as a station receiver, you will find two rather simple changes improve its usefulness considerably. The first is to add an on-off switch, snap or toggle type, to disconnect the B battery during periods of transmitting; this can be mounted anywhere on the front panel, and wired between the B-negative lead to the battery and the soldering lug which is the common chassis connection. (Of course, when you are through with the receiver for the day, be sure to disconnect the filament batteries or they will run down rapidly.) The second improvement is the addition of a second tuning condenser of smaller capacity, as a *bandspread* device for ease of tuning. For this, buy another variable condenser like the two you have, but of only 20 $\mu\mu$fd. capacitance (such as Millen No. 20920). Remove the present tuning condenser, and put the smaller one in its place. Then take the original tuning condenser and mount it on the left rear of the chassis, as shown in Fig. 11. Run a wire from the shaft (movable plates) connection to the common chassis point, and run another wire from the stator (fixed plates) to the point on the coil socket which is the end of coil L_1 going to the little fixed grid condenser, C_3. Thus you have wired the original tuning condenser and the new, smaller one in *parallel*, so that they work together. Get a small pointer knob for the big tuning condenser. Now, you will find that you can set the main tuning condenser, on the back of the chassis, at any point and the smaller tuning condenser now controlled by the big dial will permit you to tune much more slowly over a small portion of the spectrum. In this way you will find that the amateur 80-meter band will spread itself over the entire dial — in fact, it will be necessary to have two different settings for the main condenser (on the chassis) to permit covering the entire band in two sections. As a final adjustment, you will need to remove 3 turns from the grid end (top) of coil winding L_1, so that your receiver will cover approximately the same tuning range as it did before modification; in other words, make it a total of 22 turns instead of the original 25. You will find that this receiver modification is a particular improvement in tuning the 7000-kc. band, since it spreads the frequencies over a number of dial divisions whereas in the basic receiver design only a couple of dial divisions include the entire band. After you find the right settings, make small pencil marks on the chassis so that you can reset the main tuning condenser knob to the same point each time you want to listen on a particular range.

Interpreting What You Hear

Now that you have finished building your receiver, mastered its operation, and experienced that indescribable thrill of receiving signals over a product of your own hands, you will most likely want to get down to the serious business of copying amateur radio telegraph stations in order that you may acquire speed and proficiency in reception.

Call signs are quite readily identifiable, since they are usually repeated several times, so it is probable that they will be the first symbols you can recognize from the jumble of dits and dahs emitting from your receiver headphones.

By confining your more serious listening to the 3500-kc. amateur band, as we suggest you do, practically all of the stations you hear will be in the United States. All amateur calls within the United States boundaries consist of the prefix W or K, followed by a figure (1 to Ø) and then a combination of two or three letters. Such calls might be W1AW, W3IEM, W6TI, W9LFK or WØKYX. Novice call signs have the prefix WN or KN and you will hear such stations in the portion of the band 3700-3750 kc. The U.S. is divided into ten call areas for licensing purposes and from the number in the call you will be able to tell the general area of the country in which the station is located (see map, Fig. 12). Although unlikely on the 3500-kc. band, you may hear foreign stations signing prefixes such as G (England), F (France), XE (Mexico) and of course our Canadian neighbors, VE. When one station calls another it sends the call of the station being called several times, then the letters "de" (meaning

"from" in French, and agreed upon internationally as the sign to separate the call of the calling station from the call of the station being called) and then its own call repeated a number of times. If you hear this on the air — W2KH W2KH W2KH DE W1AW W1AW W1AW — it means that W1AW is calling W2KH. Many times what you hear will be like this: CQ CQ CQ DE W2AEN W2AEN W2AEN. "CQ" is a general call to any station which may want to talk with the station doing the calling, and in the case we have cited means that W2AEN is indicating that he is ready to talk with anybody and will answer any station he may hear.

When you first start "copying" stations you may become confused in trying to interpret what is being sent. Don't worry — what you are putting down on paper may be abbreviations used by radiotelegraph operators to save time while talking with each other. Over the years a large number of these have become standardized through common usage. For your information, we list some of the more common abbreviations in use on the ham bands:

ABT	About
AGN	Again
AMP	Ampere
ANI	Any
BCNU	I'll be seeing you
BK	Break
BTR	Better
CRD	Card
CUD	Could
CUL	See you later
DX	Distance
ES	"&"
FB	Fine business, excellent
FM	From
FR	For
GA	Go ahead, good afternoon
GE	Good evening
GG	Going
GM	Good morning
GN	Good night
GUD	Good
HAM	Amateur
HI	Laughter
HR	Hear, here
HRD	Heard
HV	Have
HW	How
NIL	Nothing
NR	Number, near
NW	Now
OB	Old Boy
OM	Old Man (all male amateurs are "OMs" regardless of age!)
OP	Operator
OW	(Old Woman) A married woman operator, sometimes called "XYL"
PSE	Please
RCVR	Receiver

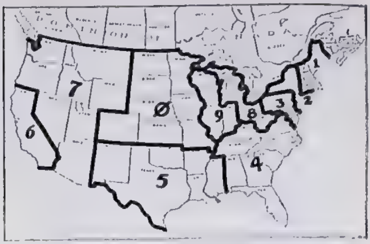


Fig. 12 — Amateur call areas in the United States.

SED, SEZ	Said, says
SKED	Schedule
SRI	Sorry
TKS, TNX	Thanks
TT	That
TU	Thank you
U, UR	You, your, you're
VY	Very
WL	Well
WX	Weather
XMTR	Transmitter
YL	(Young lady) An unmarried woman or girl operator
73	Best regards

Another group of abbreviations used by radio amateurs is the internationally-recognized "Q" signals. The "Q" signals constitute a handy way for amateurs — or any class of radio station — to exchange certain kinds of information without having to spell out long sentences. In addition, whatever the language be, "Q" signals have the same meaning; therefore they are a helpful way of exchanging information between two operators of different nationalities who do not speak each other's language. A French amateur sends "QTH?" and the American amateur he is in contact with knows he is asking for his address and replies "QTH 17 Pine Street, Podunk Hollow, Nebraska," or whatever it may be. A partial list of "Q" signals appears in the appendix of this booklet.

One of the first adjuncts to your "shack" should be a callbook, so that you can locate the stations whose calls you hear over the air. The ARRL does not publish an amateur callbook but an excellent one is available known as *The Radio Amateur Callbook Magazine.* It gives the calls of all United States and foreign amateur stations and should be on every operating table. It may be secured for $3.00 postpaid from the publishers (The Radio Amateur Callbook Magazine, 608 South Dearborn St., Chicago, Ill.).

A Simple Transmitter

Now that you are well "organized" for listening on the amateur bands, and are preparing for an amateur license, you are ready to begin thinking about a transmitter with which you can converse with fellow radio amateurs. In the case of a receiver the decision of whether to build or to buy often results in the purchase of a ready-built receiver. In the transmitter field, however, the picture is just the opposite — nearly every amateur station uses a home-built transmitter. The problem of whether to build or buy is much easier to decide when we discuss transmitters, because a transmitter can grow, like Topsy. That is, you can start off with a low-powered oscillator, and add higher-powered amplifiers as your skills and finances permit. So, about the only decision

necessary is that of how simple, or how elaborate, you want your first transmitter to be. As in the case of the receiver, we recommend that you build a very simple one to start with — it keeps your initial outlay of cash small, you get a good deal of experience in construction and practical operation, and the components can be used again in later transmitter designs you may decide to build.

What we are going to describe now is a very inexpensive *crystal-controlled* transmitter of one tube. First of all, what do we mean by a "crystal-controlled" transmitter? Basically, a transmitter is simply a vacuum-tube oscillator designed to deliver radio frequency power to a radiating antenna. You'll remember in the section on "How Radio Works" that we discussed *resonance* of tuned circuits. With coil and condenser combinations of the proper sizes we can tune to various frequencies. That's just how we tune our simple receiver (or any receiver, for that matter) — by adjusting the capacity of a variable condenser which is connected across a coil. We could use this same method to control the frequency of a transmitter oscillator, and many amateur transmitters are so constructed. However, rather elaborate precautions are necessary to keep the signal clean and free from "chirps" or other signs of instability. For a beginner, there is a simpler and safer way to control transmitter frequency, and that is by means of a quartz crystal. By using crystal control it is far easier to achieve a clean, stable signal. The crystals used in amateur transmitters are thin wafers of quartz mounted between two metal plates. A crystal has the property of vibrating at some frequency, determined by the size of the quartz plate, when a voltage is applied to it. This is known as the *piezo-electric effect.* The quartz crystal takes the place of a coil and condenser combination, and as a result the transmitter will operate on only one frequency. In order to operate on more than one frequency in the same band it would be necessary to have more than one crystal. But, by using crystal control, you can be fairly certain that the stability of your transmitter satisfies FCC requirements.

This one-tube transmitter is designed to operate in the 80- and 40-meter amateur bands, using but a single 80-meter crystal for operation in both bands. Operation on the 40-meter band is accomplished by "doubling", meaning that the transmitter is adjusted so that the output frequency is twice, or "double," the crystal frequency. Thus, since the telegraph band extends from 7000 to 7200 kc., you should use an 80-meter crystal whose frequency lies between 3500 and 3600 kc. (half of 7000 and 7200, respectively). It would actually be better if you bought a crystal somewhere between 3505 and 3595 kc., thereby allowing yourself a margin of safety. However, if your aim is for a Novice Class license (see later discussion under "Licenses") you will want to get a crystal for one of the 80-meter band frequencies open to Novice operation — that is, between 3700 and 3750 kc.; you could use this only on the one band, of course. For 40-meter Novice operation, you will need a separate crystal since these two Novice bands are not "harmonically-related" (even multiples) and the "doubling" system will not work out to locate you in the Novice frequencies 7175–7200 kc.

Reference to the photographs will show you how simple this little transmitter is. To minimize the tools required, a simple chassis of wood is built. To be really fancy you can finish it with

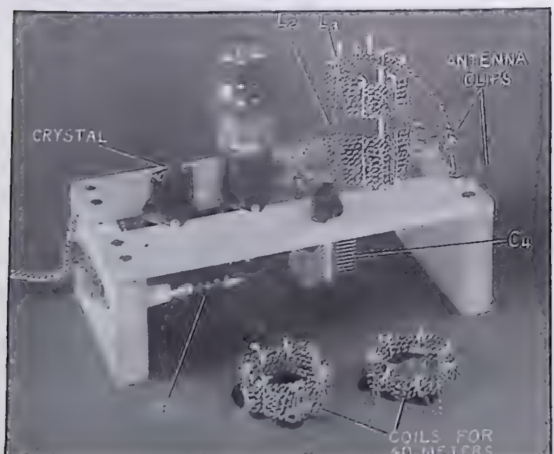


Fig. 13 — A close-up of the simple transmitter, showing details of construction.

clear lacquer or dip it in hot paraffin. This might help its electrical efficiency a bit, but isn't essential. Two 1¾ × 9¾-inch strips of ¼-inch-thick wood are fastened with screws to two 4½″× 2½ × ¾-inch end pieces, leaving enough separation (about 1 inch) between the strips to fasten the octal sockets used for the crystal and the tube. Wood screws can be used to mount the sockets, or they can be bolted to the wood strips with 6–32 machine screws. The key of the tube socket (the key is the little indentation in the round hole through the center of the socket) should be mounted toward the front of the transmitter, for convenience in wiring the plate circuit to the tuning condenser. The tuning condenser (C_4) may not have a long-enough mounting shank (threaded bushing) on it, in which case it will be necessary to first drill a clearance hole for the shank and then dig away — or counterbore — clearance for the nut. The two Fahnestock clips for the antenna are secured under two of the screws used for fastening the wood strips to the right-hand end piece, and the other two clips used for the key leads are held down by machine screws on the left-hand end piece. The r.f. choke (*RFC*) is held in place on the left-hand end piece by a machine screw. The four wires used for a power cable are brought out at the rear left under the wood strip — a half-round hole being filed or cut with a knife to clear the wires.

The plate coil (L_2) and antenna coil (L_3) are held in place on three small sticks set in the top of the chassis — penny suckers are a good source for these sticks! Drill holes a hair larger than the sticks, and then glue them in; if you don't have a drill large enough, whittle the end of the stick to fit the drill you do have. The plate coil connects, at the bottom, to a brass machine screw soldered to a lug which in turn is soldered to the stator terminal of the tuning condenser, and the screw is built up most of its length by adding nuts or small spacers to it. The screen (B+) end of the coil, the top end of the winding, is fastened to a brass screw that runs through the rear wood strip. The coil ends have lugs soldered to them to facilitate band-changing, but this refinement isn't absolutely necessary. The antenna-coil ends are connected by fastening their lugs to two brass screws supported by short lengths of heavy wire (antenna wire, for example), the wire being soldered to the Fahnestock clips and to the heads of the screws.

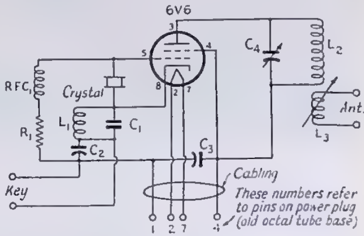


Fig. 14 — Schematic diagram of the wiring of the little transmitter.

Wiring the little transmitter isn't much of a job. See Fig. 14 for the circuit diagram. As can be seen from the photographs, the wiring is done with the same wire that is used for the coils, because a single 50-foot roll of No. 18 bell wire, available in any five-and-ten or hardware store, suffices for the whole rig with some to spare. To ensure good electrical contact, the wire is soldered at every connection, which means that the wire is soldered to the heads of the brass machine screws used for the key leads and the screen end of L_2 before the screws are put in place. One key lead, one end of R_1, the outer foil (usually marked "ground") connections on C_2 and C_3, and the lead to the negative side of the power supply are all connected to Pin 1 of the tube socket. At the crystal socket, two adjacent pins (for example, 1 and 8) are bonded together for the grid side of the crystal and the next two pins (2 and 3) are bonded together for the cathode side. This permits plugging the crystal into either Pins 8 and 2 or 1 and 3.

The coil in the cathode circuit (L_1), consisting of 5 turns of No 18 bell wire, is wound on a 1½-inch diameter form and then removed and tied with string at a number of places. One might think that the coil would fall apart when it is removed from the form, but the wax on the insulation of the wire helps to hold it until a few pieces of string have been tied in place. The cathode coil is mounted by its leads only but, being short, they offer adequate support.

The plate and antenna coils are wound in a simple fashion that was popular in the early days of ham radio and that is still practical for anyone trying to save on coil forms. Laboratory tests

Parts List for Simple Transmitter

C_1 — 470-μμfd. mica condenser
C_2, C_3 — 0.01-μfd. 600-volt paper condenser
C_4 — 140-μμfd. variable condenser (Bud MC1876)
R_1 — 0.1-megohm 1-watt composition resistor
L_1 — 5 turns No. 18 d.c.c. (bell wire), 1¼-inch inside diameter
L_2 — *3.5 Mc.*: 19 turns. *7 Mc.*: 12 turns (see text for method of winding)
L_3 — *3.5 Mc.*: 13 turns. *7 Mc.*: 6 turns (requires experiment to get exact number of turns needed)
RFC — R.f. choke, 2.5 mh. (National R-100U)
Type 6V6 tube
2 octal bakelite sockets
1 50-foot roll of bell wire
4 Fahnestock clips, ¾ inch
3 thin dowels (lollipop sticks), 4 inches long.
1 knob for tuning condenser.
1 quartz crystal — see text for choice of frequency (Peterson, Bliley, etc.)
1 old tube base (for power plug)
3 pieces of wood for chassis (see text for sizes)
1 radiotelegraph key
Soldering lugs and miscellaneous small hardware such as wood screws, 6–32 machine screws and nuts.

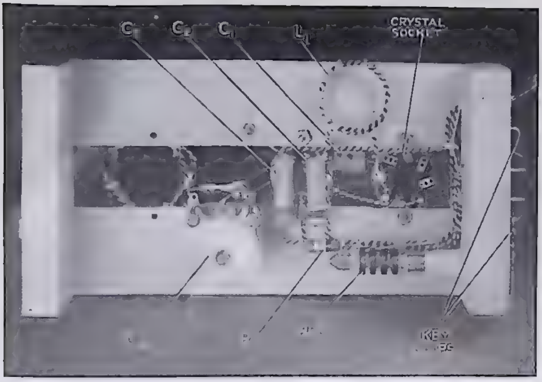


Fig. 15 — Showing the mounting of parts underneath the "chassis."

show that these coils have good characteristics, and so you need have no qualms about using this type of coil construction. They are wound by equally spacing seven nails on a 2-inch diameter circle, driving the nails completely through the board used so that the heads are flush against the board. See Fig. 16. Small spikes can be used, or nails of the "8-penny" size will be satisfactory

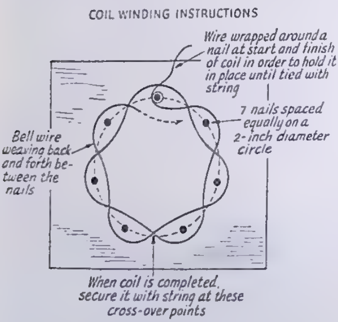


Fig. 16 — Method of winding coils for the simple transmitter.

if a thin board is used. One end of the wire is secured to a nail and the wire is threaded over alternate nails, May pole fashion, so that the coil repeats itself every two turns. When the required number of turns has been made, the end of the wire is wrapped around a nail and the coil tied together with string at the seven cross-over points. The result is an inexpensive coil having fair mechanical properties and good electrical ones, and it is difficult to build one any more cheaply. Soldering lugs are soldered to the ends of the coil for ease in changing bands, though this isn't absolutely necessary, as mentioned earlier. If you don't use lugs, simply wrap the bared end of each wire around the appropriate machine screw and fasten with a nut.

The four wires coming out the side of the chassis that go to the power supply are twisted together slightly and cabled with string to form a neat cable. For convenience they should be labeled for identification using small tabs of paper and Scotch tape. These wires run to an old tube base which plugs into the power socket in the power supply. Get yourself an old octal-base glass tube (any radio service shop has some burned-out tubes of this description), and remove the glass and the cement. Watch out for your eyes in breaking the glass — the best way is to enclose the tube in a rag and hit it with a hammer. Clean out the pins with your soldering iron, removing all the solder and wires already in the pins. Then connect the wires from the transmitter to the appropriate pins in this power plug that you have just made for yourself. See Fig. 14 for the correct pin connections.

Building the power supply is even easier. You could use several B-batteries, but they would run down quite rapidly, so a much better source of power for a transmitter is one which takes the regular a.c. voltage in your house, steps it up through a transformer (T_1, Fig. 17) converts it into direct current through a *rectifier* tube, and then "purifies" it by means of a filter choke (L_1) and two filter condensers (C_1, C_2). This pure direct current is necessary for your plate power supply to ensure a clean, sharp signal. The fila-

Parts List for Simple Transmitter Power Supply

T_1 — Power transformer, 350 volts each side of center tap, 70-ma. (Thordarson TS-24R02)
L_1 — Filter choke, 12 henrys, 80 ma. (Thordarson T-20C53)
C_1, C_2 — 8-μfd. 450-volt electrolytic condensers
R_1 — 25,000 ohms, 25 watts
5Y3 rectifier tube
3 pieces of wood for chassis (see text for sizes)
2 bakelite octal sockets
1 male plug for 115-volt supply
Miscellaneous wood screws, etc.

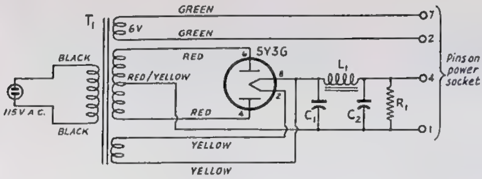


Fig. 17 — Circuit diagram of the power supply.

ment voltage can be a.c., so that is taken from a small winding on the transformer.

In this power supply, the same style of construction as in the transmitter is used. The photographs (Fig. 18) will show you the general layout of parts. Two 10 × 1½ × ¾-inch pieces of wood form the top of the chassis, with two pieces 4⅝ × 1½ × ¾-inch for the ends. Eight flathead wood screws 1¼-inch long are used to fasten the pieces of wood together, while round-head woodscrews ½-inch long hold down the sockets and the filter choke. The power transformer is held in place by means of two round-head woodscrews 2 inches long. The lead going to the 115-volt a.c. line is passed through a ¼-inch hole drilled through the end piece directly below the power transformer. The socket at the opposite end from the power transformer is for the power plug from the transmitter. It would be quite possible to use Fahnestock clips instead of this socket, and such an arrangement would be a little easier mechanically, but it would be nowhere near as safe, since the high-voltage would be exposed. Even though this is not a high-powered transmitter, it does use about 350 volts. That can easily be lethal, so use the greatest care and respect when working with it. Remember, too, that the same voltage exists at certain points on the transmitter.

See the schematic of Fig. 17 for the wiring diagram of the power supply. There are only about a dozen connections, and no coils or adjustments to be made, so you should have no difficulty.

Okay — now to see if your little transmitter works. Double-check the wiring, and then connect the 7-Mc. plate coil in place. Plug in the crystal (making sure its pins hit the right holes) and the tube, insert the power plug in the power supply, and connect a key or switch to the key clips on the side of the transmitter. Set the plate tuning condenser, C_4, at about 40 per cent meshed and turn on the power. When the tube has had time to warm up — about 30 seconds — close the key and touch a neon bulb to the plate end of L_2. Or a small 10-watt electric lamp can be connected to the antenna posts with the 6-turn antenna coil in place. If C_4 is set properly, the neon bulb will glow or the lamp will light. If this doesn't happen, try tuning the plate condenser until signs of output become apparent. The transmitter can then be checked on the 3.5-Mc. band by putting in the proper coils. Don't forget, however, that you're dealing with electricity, which can be lethal. Turn off that power supply and discharge the filter condensers by closing the key for a second or two. In other words, *don't stick your hand in your transmitter when the power supply is on.*

It is, of course, impossible to specify a transmitting antenna that will suit everyone's location. First of all, a transmitting antenna should not be a haphazard length of wire like that used on your receiver. It must be rather carefully cut to a length which is determined by the frequency on which you will operate, and the manner in which the radiating portion of the antenna is fed from the transmitter requires consideration. The subject of antennas is a fascinating one, and

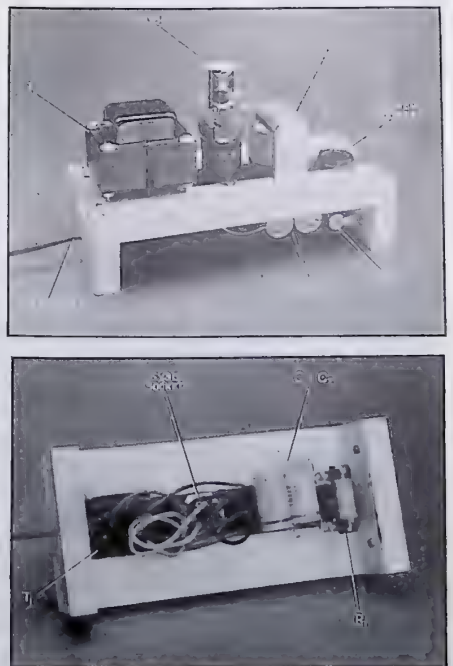


Fig. 18 — Top and bottom views of the power supply for the simple transmitter.

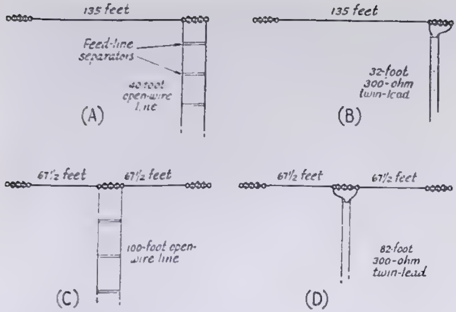


Fig. 19 — These are suggested antennas for use with the simple transmitter. The wire used should be about No. 14 enameled copper. An "open wire" feed line is one in which the two wires of the line are separated by insulated spacers 4 or 6 inches long. In (a) and (b) one side of the feed line connects to the antenna proper, while the other side terminates in no connection at all. This is known as a "Zepp" antenna. In (c) and (d) the antenna is cut in the center and held together by another antenna insulator; the feed lines connect to each side. The Twin-Lead feed line shown in (b) and (d) is very convenient. Rope halyards can be used to support the antenna between a couple of houses or trees. In general, the higher the antenna above the ground, the better it will radiate.

the construction of a good antenna system really pays off in increased station efficiency. Fig. 19 shows some simple antenna systems which will enable you to get on the air. Connect a flashlight bulb between the end of one antenna "feeder" wire and its clip on the transmitter. This routes the antenna current through the bulb so you can make adjustments of tuning, spacing between L_2 and L_3, and the number of turns on L_3, to get the brightest light. If you get no indication of current, you may have to put a 100-$\mu\mu$fd. variable condenser in parallel with (across) the antenna terminal clips — or in series (between one feed line and its clip) — to hit resonance.

If room for only a short length of wire is available for the antenna, say 40 or 50 feet, it is best to connect its end to one antenna post and a good ground to the other. Here again some experimentation will be necessary to determine the optimum size of L_3.

Going back for a moment to this business of testing your transmitter, *don't connect it to an antenna unless you have your amateur license.* There are severe penalties for putting a signal on the air without a license. If you build a transmitter before your license comes through, use that 10-watt lamp as a load for your transmitter. A lamp connected across the antenna coil in that fashion is known as a "dummy antenna," and should always be used when you wish to test a transmitter without causing interference to other stations.

More Advanced Equipment for the Beginner

The limitations of the regenerative receiver and the one-tube transmitter have been discussed earlier. It has been said that it will probably not be long before you will be looking toward equipment with better performance and operating conveniences. One of the things that makes amateur radio the intriguing hobby that it is, is that there are always new horizons to look to — in equipment as well as in operating.

While a simple regenerative receiver will permit you to get on the air at a minimum of cost and time devoted to construction, most of today's amateurs use receivers of the superheterodyne type. The performances of the two types can

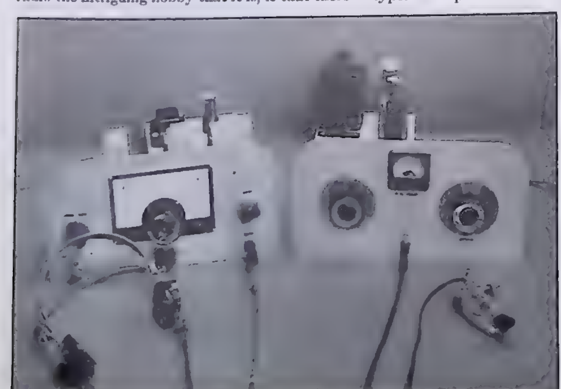


Fig. 20 — This equipment will cost a little more and take somewhat longer to build, but its performance will be greatly superior to that of the units previously described. A four-tube superhet receiver is to the left and an oscillator-amplifier transmitter to the right. Each has its own attached power supply at the rear.

hardly be compared. Signal strength, stability (steadiness of frequency) and selectivity (ability to separate signals near the same frequency) will be much superior with the superhet, and the critical adjustments associated with the regenerative receiver are eliminated.

In the same way, while results satisfactory for low-power work are readily obtained with a single-tube transmitter, it is possible to secure greater output and to strike a better balance between simplicity and cost in proportion to power by the addition of a simple amplifier.

A Four-Tube Superhet Receiver

Perhaps the word "superheterodyne" sounds ominous and seems to imply great complexity. This impression should be dispelled at once. Actually, a simple superhet is no more than a grouping of several circuits, each one of which is no more difficult to understand than the regenerative-receiver circuit, while the adjustment for satisfactory operation usually is much easier. Almost anyone capable of mastering the regenerative receiver should have little difficulty with the superhet shown in Figs. 21, 23 and 24. The cost will be greater — approximately $45.00 exclusive of power supply and headphones if all components are purchased new — and it will take a little longer to build. But it should take less time and experience to adjust.

The Superhet Circuit

The circuit is shown in Fig. 22. Note how the different sections are labelled, and digest them one at a time. The converter section — from L_2 to T_1 — is the important part. It serves to *convert* the frequency of the incoming signal to another frequency before it is amplified. The signal from the antenna is fed through the wave trap (which will be explained later) to the antenna coupling coil, L_2. L_2 serves to transfer the signal to the input circuit of the converter. The input circuit consists of L_3 and C_2. It is tuned to the frequency of the incoming signal by C_2. The signal is applied to the control grid (Pin 8) of the 6SB7Y.

C_3, C_4, L_4 and L_5 are the essentials of a high-frequency oscillator circuit. The screen of the 6SB7Y serves as the "plate" in this oscillator circuit. Although arranged somewhat differently, its resemblance to the regenerative-detector circuit may be recognized. The difference here is that the circuit oscillates strongly all of the time without the necessity for critical adjustment. The oscillator signal combines with the antenna signal in the 6SB7Y to produce in the plate circuit a signal whose characteristics are the same as those of the original signal except that the frequency has been changed. This new frequency is called the *intermediate* frequency (i.f.). The signal is now fed to an amplifier tuned to the new frequency. T_1 and T_2 are tuned permanently to the i.f. Since all incoming signals will be converted to this same i.f., there is no need to retune the i.f. amplifier after it has been set initially. The gain or amplification in the i.f. amplifier (and thereby the signal volume) may be varied by R_5.

Now we have a signal at the output of T_2 that looks exactly like the signal coming from the antenna except that it is at a different frequency. So it must now be passed to a detector. Since the signal has been amplified by other means, regeneration is not needed. The signal is detected by the simple diode-rectifier section of the 6SQ7, The rectified signal appears across the resistor R_9. A modulated signal is now at audio frequency. and it could be heard if the headphones were con-

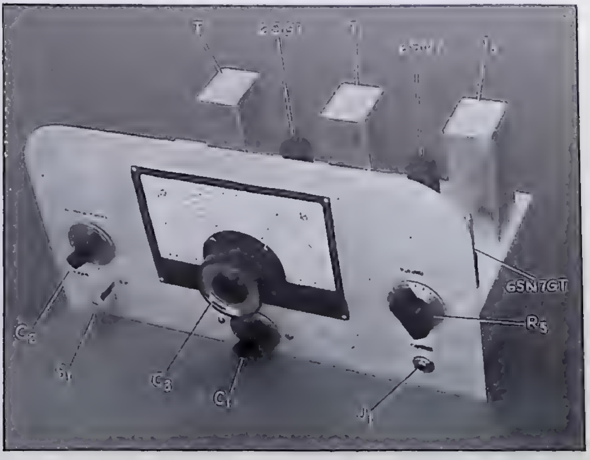


Fig 21 — A four-tube superhet receiver covering the 3.5-, 7- and 14-Mc. bands as well as spots in the commercial point-to-point and short-wave broadcast bands with only two pairs of coils.

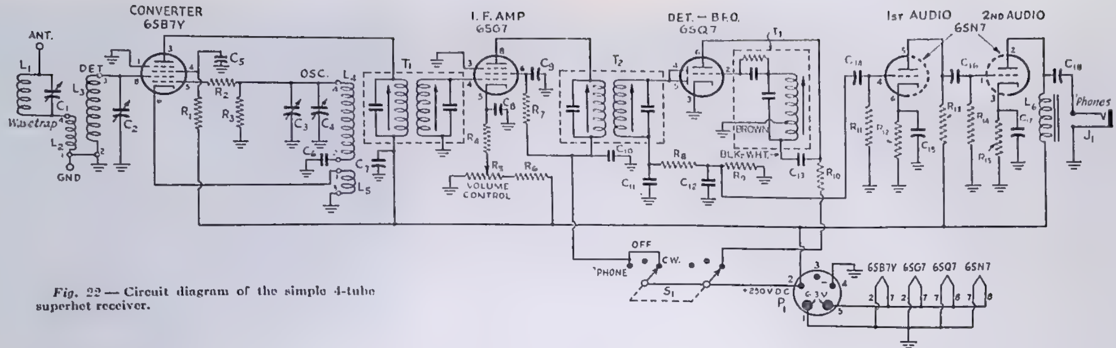


Fig. 22 — Circuit diagram of the simple 4-tube superhet receiver.

C_1 — Wave-trap tuning condenser — 335-μμfd variable (National STH-335 or Bud MC-1860).

C_2 — Input-circuit tuning condenser — Same as C_1.

C_3 — Oscillator bandspread tuning condensor — 50-μμfd. variable (National ST-50 or Bud MC-1853).

C_4 — Oscillator padder or band-set condenser — 150-μμfd. mica compression-type trimmer condenser (El-Menco 463).

C_5 — Converter screen by-pass condenser — 0.1-μfd. 150-volt paper.

C_6 — Oscillator grid blocking condenser (prevents short-circuit of R_3 through L_4) — 0.001-μfd. disk ceramic (Sprague 29C4).

C_7 — Converter plate by-pass — 0.1-μfd. 600 volt paper.

C_8 — I.f. cathode by-pass — 0.1-μfd. 150-volt paper.

C_9 — I.f. screen by-pass — 0.1-μfd. 150-volt paper.

C_{10} — I.f. plate by-pass — 0.01μfd. disk ceramic (Sprague 36C1).

C_{11}, C_{12} — I.f. filter condensers — 100-μμfd. mica.

C_{13} — B.f.o. plate blocking condenser (prevents shorting of d.c. through T_3) — same as C_6.

C_{14}, C_{16} — Audio coupling condensers — 0.01-μfd. paper.

C_{15}, C_{17} — Audio cathode by-pass condensers — 10-μfd. 25-volt electrolytic.

C_{18} — Headphone coupling condenser — 0.1-μfd. 600-volt paper.

R_1 — Converter screen voltage-dropping resistor — 12,000 ohms, 2 watts.

R_2 — V.h.f. parasitic-suppressor resistor — 47 ohms, ½ watt.

R_3 — Oscillator grid leak — 22,000 ohms, ½ watt.

R_4 — I.f. cathode biasing resistor — 220 ohms, ½ watt.

R_5 — I.f. gain control (varies bias) — 5000-ohm volume control.

R_6 — I.f. gain-control voltage-dropping resistor — 82,000 ohms, 1 watt.

R_7 — I.f. screen voltage-dropping resistor — 47,000 ohms, 1 watt.

R_8 — I.f. filter resistor — 47,000 ohms, ½ watt.

R_9 — Detector load resistor — 0.33 megohm, ½ watt.

R_{10} — B.f.o. parallel-feed resistor — 47,000 ohms, 1 watt.

R_{11}, R_{14} — Audio grid resistors — 0.22 megohm, ½ watt.

R_{12}, R_{15} — Audio cathode biasing resistors — 1500 ohm 1 watt.

R_{13} — Audio plate resistor — 47,000 ohms, 1 watt.

L_1 — Wave-trap inductance — 24 turns No. 20 wire, 1 inch diam., 1½ inches long (B & W 3015 Miniductor).

3.5- and 7-Mc. coils:

L_2 — Antenna coupling coil — 6¼ turns No. 22 d.s.c. wire, 1 inch diam., turns close-wound (see text).

L_3 — Converter input coil — 14¼ turns No. 22 d.s.c. wire, 1 inch diam., close-wound (see text).

L_4 — Oscillator tuning inductance — 16½ turns No. 22 d.s.c. wire, 1 inch diam., close-wound (see text).

L_5 — Oscillator feed-back coil — 3¼ turns No. 22 d.s.c. wire, 1 inch dia., close-wound (see text).

14-Mc. coils:

L_2 — 3¼ turns No. 22 d.s.c. wire, 1 inch diameter, close-wound (see text).

L_3 — 8¼ turns No. 22 d.s.c. wire, 1 inch diameter, close-wound (see text).

L_4 — 3½ turns No. 22 d.s.c. wire, 1 inch diameter, turns spaced to occupy length of ⅛ inch. 320-μμfd silvered mica condenser connected across this winding (see text).

L_5 — 2¼ turns No. 22 d.s.c. wire, 1 inch diameter, close-wound (see text).

L_6 — Audio parallel-feed choke — 20-h. 15-ma. filter choke (Stancor C-1515).

J_1 — Open-circuit headphone jack.

S_1 — 'Phone-c.w. switch — Double-pole, triple-throw rotary switch (Mallory 3123J).

T_1, T_2 — 1500–1600-kc. i.f. transformers (Millen 64161).

T_3 — 1500–1600-kc. b.f.o. unit (Millen 65163).

nected across this resistor. However, the signal will be much louder if it is amplified in an audio-frequency amplifier. Therefore, the signal across R_9 is fed to the grid of the first section of a dual-triode audio-amplifier tube. The signal output from the first section is fed to the grid of the second section. The headphones are connected in the output circuit of this second amplifier. The choke, L_6, makes it unnecessary to pass the d.c. plate current of the 6SN7 through the headphones (parallel plate feed).

Now we remember that in order to hear c.w. (unmodulated) signals in the regenerative receiver we had to make the *detector* oscillate. A diode detector cannot be made to oscillate. So, instead, we provide a separate oscillator called the *beat-frequency* oscillator (b.f.o.). The b.f.o. operates at the i.f. The triode section of the 6SQ7 and T_3 are used for this purpose. The b.f.o. is turned off by the switch S_1 when the switch is in the 'phone position where the b.f.o. is not needed. The switch also silences the receiver when it is turned to the mid position. This is desirable while the transmitter is being operated.

Converter Tuning System

Returning to the converter circuit, when the oscillator is tuned to some chosen frequency, the superhet can be made to respond to any antenna signal whose frequency *differs* from the oscillator frequency by the frequency to which the i.f. amplifier has been tuned. This means that there are two signal frequencies to which the receiver will respond for each setting of the oscillator frequency — the oscillator frequency *plus* the i.f., and the oscillator frequency *minus* the i.f. Thus if the *oscillator* is tuned to 5000 kc. and the i.f. amplifier is set at 1500 kc., the *system* will respond to signals at 5000 plus 1500 = 6500 kc. and at 5000 minus 1500 = 3500 kc. Either of these two signals may be selected by tuning the input circuit, L_3C_2 to one or the other. If the input circuit is tuned to 3500 kc., the signal at 6500 is called the *i.f. image* signal. If the input circuit is tuned to 6500 kc., the 3500-kc. signal then becomes the image. In other words, the *unwanted* signal is always called the image. The degree to which the input circuit can discriminate against the image signal is known as the receiver's *image rejection.*

In more-advanced superhet design, the tuning condensers of the input circuit and the oscillator circuit are ganged together so that the input circuit always will be tuned to the desired side of the oscillator frequency. However, in this instance, the tuning controls are independent so that advantage may be taken of the dual-response characteristic. The oscillator is designed to cover, by adjustment of C_3, the range of 5000 to 5800 kc. and the i.f. is set permanently at 1500 kc. Therefore, when we *subtract* 1500 kc. from the oscillator range, we get the signal range of 3500 to 4300 kc. and when we *add* 1500 kc. to the oscillator range, we get the signal range of 6500 to 7300 kc. The *input* circuit is designed to tune over both of these ranges. It will be seen that the amateur 80-meter band lies in the first range, while the 40-meter band is included in the second range. It is necessary merely to shift the setting of C_2 to select either range.

Since the selectivity of the single tuned circuit L_3C_2 may not be sufficient to exclude a strong image, the additional tuned circuit L_1C_1 in the wave trap is made available. Connected in series with the antenna as shown, this circuit will tend to *reject* any signal to which it is tuned. Thus, if we are listening to a signal in one of the two ranges and we get interference (as we may) from a strong signal in another range, adjustment of C_1 to the frequency of the interfering signal will help greatly to eliminate it.

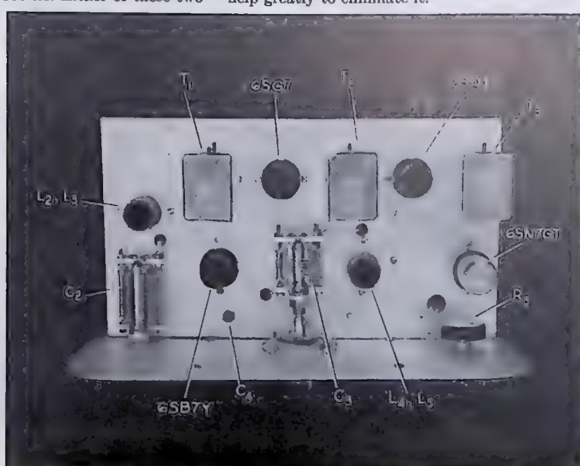


Fig. 23 — Rear top view of the superhet receiver showing the placement of parts on top of the chassis.

Additional Tuning Ranges

The output of the usual type of oscillator — whether in a receiver or transmitter — is seldom confined exclusively to the fundamental frequency to which its circuit is tuned. It always produces output to a greater or less degree at exact multiples of the fundamental frequency. These multiples are called *harmonics*. The output at twice the fundamental frequency is called the second harmonic; output at three times the fundamental frequency is called the third harmonic, and so forth. The power output usually falls off quite rapidly as the number of the harmonic increases. However, the output of the oscillator at the second harmonic in this receiver is great enough so that use may be made of it in obtaining two additional listening ranges from the same set of coils.

The oscillator's fundamental range we know is 5000 to 5800 kc. The second-harmonic range therefore will be twice this, or 10,000 to 11,600 kc. Now when we add the 1500-kc. i.f. we get a signal range of 11,500 to 13,100 kc. When we subtract the i.f. we get the range of 8500 to 10,100 kc. These ranges are also included within the coverage of L_3C_2.

Construction

In building this receiver and the two-tube transmitter which follows, a few tools in addition to the usual hand tools, such as screwdriver, pliers, etc., should be borrowed or purchased Socket holes are most easily cut with a socket-hole punch (such as Greenlee or Pioneer). Large holes also may be cut readily in aluminum with an adjustable circle cutter in an ordinary carpenter's brace. Small holes can be drilled with a hand drill of the "egg-beater" type and reamed out to larger size with a large drill held in the brace. Small drills can also be used in the brace, if a hand drill is not available. Always mark the hole centers with a prick punch before attempting to use the drill.

Don't start to build this receiver with the idea that you are going to complete the job over a weekend. Take your time and do a careful job. By this we don't mean that the mechanical workmanship must be perfect. Simply make sure that the parts are mounted securely and that the wiring doesn't end up in a rat's nest. It will pay you in results and freedom from trouble in getting the receiver into operation.

The unit is assembled on a standard chassis 7 by 13 by 2 inches. Aluminum is much easier to work with than steel — particularly with simple tools — and the cost is about the same. The panel is cut from a sheet of 1/16-inch aluminum 7½ inches high and 14 inches long. If it is desired to put the receiver in a cabinet, the panel furnished with the cabinet may be substituted.

In laying out the chassis, the first thing to do is to spot the centers for the components on top of the chassis using Fig. 23 as a guide. The exact placement is not at all critical. To provide for a good-looking arrangement of controls on the panel, the oscillator tuning condenser, C_3, should come at the center and the input tuning condenser, C_2, should be placed at the left-hand end of the chassis where its shaft will balance the shaft of the volume control on the right. C_3 will have to be elevated about ¼ inch on metal spacers so

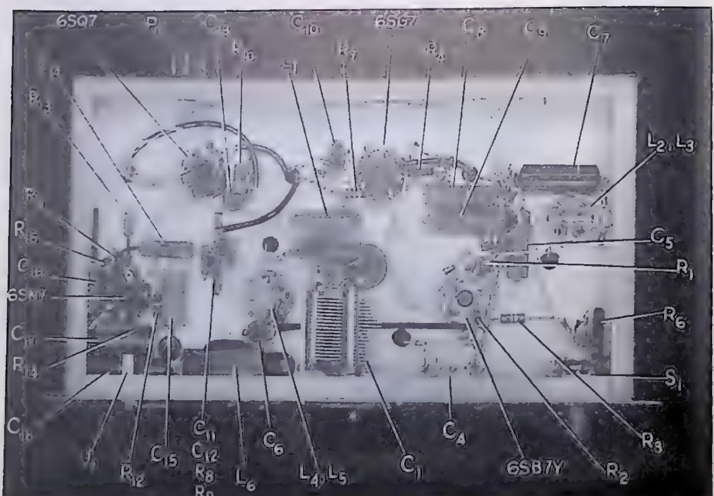


Fig. 24 — Bottom view of the simple superhet receiver. Components in the circuit diagram are identified by the arrows

that the mechanism of the National SCN dial can clear the chassis. C_2 is fastened directly to the chassis without spacers. The socket (4-pin) for the input coil (L_2L_3) should be near C_2 and the socket (5-pin) for the oscillator coil (L_4L_5) should be fairly close to C_3. The 6SB7Y socket (octal) should be about midway between the two variable condensers. The i.f. transformers and the i.f. and detector-b.f.o. tubes are lined up along the back, with the adjusting screws of the transformers toward the rear. The 6SN7 is placed in front of the b.f.o. can (T_3) in line with the oscillator coil socket and the 6SB7Y.

A 1⅛-inch punch is required for the Amphenol MIP bakelite octal sockets for the 6SG7, 6SQ7 and 6SN7, while a 1¼-inch punch is needed for the Millen ceramic sockets for the 6SB7Y and the two coil forms. The 1¼-inch punch is used also for the power plug at the rear. A similar hole should be punched in the middle of the front edge of the chassis with its center ⅞ inch above the bottom edge. You will also need a hole for adjusting the trimmer C_4 located near the 6SB7Y, and clearance holes for connections to the stator terminals of C_2, C_3, and the volume control, as well as a hole under the center of each of the i.f. cans for the transformer leads. A cut-out is required in the rear edge near the left-hand end for the antenna terminal strip, unless you decide to use a pair of small feed-through insulators as terminals. Shaft holes must be cut in the front edge for the switch and headphone jack. They should be placed at either end to balance.

C_1 is mounted under the chassis, insulated by fastening it to the center of a piece of ⅛-inch polystyrene sheet (Millen No. 55001) 3 inches long and 1¾ inches high. The insulating strip is then fastened with 6-32 screws against the inside front edge of the chassis so that the shaft of C_1 will be central in the large punched hole. C_1 is mounted with its ceramic stator bars running vertically to provide access to the mounting screws for C_3. The choke, L_6, is fastened under the chassis, next to C_1.

Before the switch, the jack and C_1 are mounted, the panel should be placed against the front edge of the chassis with the bottom edges even and the panel centered. Then the mounting holes should be transferred to the panel by marking with a scriber from the rear. The centers for the shaft holes for C_2, C_3 and the volume control should then be measured out and marked. A 1½-inch hole is needed for the mechanism of the main tuning dial.

Wiring

Time will be saved if a soldering lug is placed under each of the socket-mounting nuts when the sockets are fastened in place. They will be needed for ground connections to the chassis. Fiber lug strips fastened to the chassis by the mounting screws of the i.f. cans will provide convenient insulated anchorages for condenser and resistor terminals that should not be grounded. As Fig. 24 shows, a separately-mounted lug strip is used for mounting C_{11}, C_{12}, R_8 and R_9. The assembly is placed immediately in front of the 6SQ7 socket and fastened with a 6-32 screw.

The filament wiring should be done first, keeping the wiring down close against the chassis. The two wires of the circuit should run parallel and close together wherever possible. They may be bound together with bits of Scotch tape to keep them from spreading. Next, resistors and by-pass condensers which connect directly to tube-socket terminals should be placed, and the insulating lug strips installed wherever the free ends of the resistors and condensers must be kept away from contact with the chassis. The leads furnished with the i.f. transformers should reach the proper tube-socket terminals or to a ground lug as required, but the red leads to the plus-B line should be anchored at an insulating lug-strip terminal and the wiring extended from there. When using the Millen 65163 b.f.o. unit, the brown wire should go to ground and the black-and-white to C_{13}.

Very little r.f. wiring is required. This is the wiring between the stator terminals of C_2 and C_3 and the coil and tube terminals. No. 14 tinned antenna wire should be used and the wiring should be kept well spaced from the chassis and other components wherever possible. A small cone insulator threaded onto the rear mounting screw of the 6SB7Y socket will serve as an anchorage for the wire running from L_3 to Terminal 8 of the 6SB7Y. A lead from the front stator terminal of C_3 (a lug will have to be added at this terminal) passes down through a clearance hole in the chassis to R_2 which is soldered to Terminal 5 on the 6SB7Y socket. One terminal of C_4 is connected to this wire; the other terminal of C_4 is grounded. The mica trimmer can be supported by its connecting leads. Be sure to locate it under the adjusting hole you have drilled in the chassis. A wire from the rear stator terminal of C_3 runs to the right and then through a hole in the chassis close to the rear of the oscillator-coil socket where it is connected to Pin 4. The long wire connecting Terminal 6 of the 6SB7Y socket to Pin 1 of the coil socket is insulated with a sleeve of spaghetti and run under C_1 (in Fig. 24). Ordinary hook-up wire may be used for this connection if it is cemented to the chassis. L_1 is cut from a section of Barker and Williamson "Miniductor" and this coil is mounted directly across the rear terminals of C_1 on short lengths of No. 14 wire. Check the wiring as you proceed and go over it again after the job is completed to make sure that there are no mistakes or accidental short circuits to the chassis or other parts.

Coil Winding

In winding the coils, be sure that No. 22 d.s.c. wire is used and that the turns are tight and wound snugly together. *The proper frequency range depends on this.* Both oscillator and input coils are wound on National or Millen plastic forms 1 inch in diameter. The form for the input coil has 4 pins, while the oscillator form has 5 pins for identification. In winding L_2 and L_3, measure up on the form ¼ inch directly above Pin 4. At

this point drill a small hole to pass the No. 22 wire. Next, measure up 7/16 inch directly above Pin 1 and drill another hole. Starting with the wire at the hole above Pin 4, wind 6¼ turns in a clockwise direction with the pins facing you. This should bring you out at the second hole. Now drill a hole ½ inch above Pin 2 and another 7/8 inch above Pin 3. Starting with a new piece of wire at the lower of these two holes, wind 14¼ turns in a clockwise direction as the pins face you. This should bring you out at the top hole. The windings may be cemented in place with Duco cement or coil dope.

Special care should be used in winding the oscillator coil. Both windings *must* be wound in the same direction. Drill holes ¼ inch above Pin 5, 3/8 inch above Pin 1, 7/16 inch above Pin 2 and 15/16 inch above Pin 4. Starting at the bottom hole, wind 3¼ turns in a clockwise direction, with the pins facing you. This should come out at the second hole. Then starting at the third hole, wind

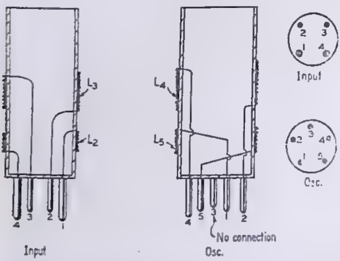


Fig 25 — Sketch showing pin connections in coil forms. Figures at right are bottom views of the coil-form bases.

16½ turns in the same direction. This should bring you out at the top hole. The ends of the wire should be scraped and fed through the proper pins, as shown in Fig. 25, and soldered. Be sure that you have followed the pin numbering shown for the coil sockets in Fig. 22. *The receiver will not work if connections to coil pins are switched or if the oscillator coils are wound in opposite directions.*

Power Supply

The receiver is designed to work from any small receiver power supply delivering 250 volts at 40 ma. or more. A suitable unit is shown in Figs. 26 and 28 and the wiring diagram is given in Fig. 27. The unit is built on a 7 × 7 × 2-inch aluminum chassis. The components may be placed in any convenient arrangement; the length of wiring leads is of no consequence. The only important point is to keep the line from the rectifier filament to

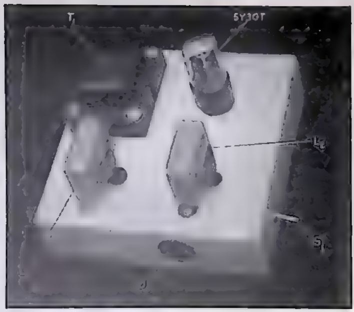


Fig 26 — A simple power supply for the superhet receiver.

the output socket (the positive high-voltage line) well insulated from the chassis. The output socket is set in one edge of the chassis so that it will line up with the plug in the receiver, and the switch and a.c. cord are placed on the side. Then the two units may be connected with a plug-in cable, or the power-supply unit can be plugged directly into the receiver chassis.

Adjustment

The receiver can be adjusted quite readily with the help of almost any superhet broadcast receiver. The Millen transformers are pretuned to 1600 kc. so must be readjusted for 1500 kc. First the b.f.o. is turned on by throwing S_1 to the c.w. position. The b.c. receiver, placed close to the ham receiver, is tuned as accurately as possible to 1500 kc. Then the slug in the b.f.o. can (T_3) is adjusted until the swish of the b.f.o. is heard in the b.c. speaker. This sets the b.f.o. at approximately 1500 kc. Next, wind several turns of insulated hook-up wire around two or three fingers. Twist one end of the wire around the turns to hold the coil in shape and leave a lead of three or four feet at the other end.

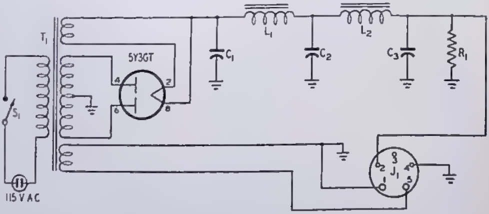


Fig. 27 — Circuit diagram of the power supply for the superhet receiver.
C_1, C_2, C_3 — Filter condensers — 8-μfd. 450-volt tubular electrolytic.
R_1 — Bleeder resistor (discharges condensers when power is turned off) — 50,000 ohms, 10 watts.
L_1, L_2 — Filter chokes — 8 h., 40 ma. (Thordarson T-20C52).
S_1 — Power switch — s.p.s.t. toggle.
T_1 — Power transformer — 250-0-250 volts r.m.s., 40 ma.; 5 volts, 2 amps.; 6.3 volts, 2 amps. (Thordarson T-22R00).

Make sure that the ends of the wire are not bare (if necessary cover them with Scotch tape) and insert the bunched wire into the back of the b.c. receiver somewhere near the tuning-condenser gang. Now put the end of the free lead into the hole in the side of the second i.f. transformer can (T_2). If the can has no hole, push the end of the wire up into the can from the bottom. Now tune the b.c. set until a whistle is heard in the headphones. It may be weak at first, so listen carefully. The whistle should be heard when the b.c. receiver is tuned to approximately 1045 kc. if the b.c. receiver has the usual 455-kc. i.f. Starting with the second i.f. transformer, T_2, adjust first the bottom slug screw and then the top screw for maximum signal in the headphones. Now transfer the lead wire to the first i.f. transformer, T_1, and adjust similarly for maximum response. Remove the test lead and turn off the b.c. receiver. The i.f. amplifier should now be tuned up at approximately 1500 kc.

Next, turn off the b.f.o. (switch in 'phone position) and set C_1 at minimum capacitance and C_2 and C_3 at maximum capacitance. Connect the antenna and adjust C_4 with a screwdriver until the background noise comes up to a maximum. By this time you should be hearing signals. Now set the main tuning dial at 50 and adjust C_2 for maximum background noise. Adjust C_4 very carefully until 75-meter 'phones are heard. Note where the high-frequency end of the 'phone band stops, and trim C_4 slightly until 4000 kc. falls at about 50 on the dial. Pick out a steady 'phone signal and go back and trim up the i.f. tuning for maximum signal (or you can use background noise). Now tune in a 'phone signal as closely as possible on the nose. Then switch on the b.f.o. and, *without additional touching of the main tuning dial*, readjust the b.f.o. (T_3) to bring the beat note (whistle) to the desired pitch.

If the oscillator coil has been wound carefully to dimensions, the receiver should now be tuned to cover 3500 to 4300-kc. In covering this band, it will be necessary to keep C_2 tuned for maximum signal. Signal strength will remain quite satisfactory if C_2 is reset only two or three times across the band, although a more accurate setting may be necessary for maximum selectivity.

To cover the 6500-to-7300-kc. range, all that is required is to set C_1 at *maximum* capacitance and readjust C_2 lower in capacitance until a second peak in background noise is heard. Then signals in and around the 7-Mc. band should be heard over the first half of the dial range. Similarly, to tune to the 8500-to-10,000-kc. and 11,500-to-13,100-kc. ranges, tune C_2 still lower in capacitance to find two more respective points where the background noise comes up. This must be done carefully for the latter two bands, since the maximum response points come quite close together near the minimum capacitance of the condenser.

14-Mc. Band

If it is desired to cover the amateur 20-meter band, a second set of coils will be required. For L_2 and L_3, drill the first hole in the 4-pin coil form 1/4 inch above Pin 4, the second hole 3/8 inch above Pin 1, the third hole 1/2 inch above Pin 2 and the last hole 3/4 inch above Pin 3. Starting at the bottom hole, wind 3 1/4 turns of No. 22 d.s.c. wire in a clockwise direction with the pins facing you. This will bring you out at the hole above Pin 1. Starting again at the third hole, wind 8 1/4 turns in the same direction. This should bring the winding to the hole above Pin 3. Solder each wire end to the pin immediately below the hole.

For L_4 and L_5, drill holes 1/4 inch above Pin 5, 3/8 inch above Pin 1, 1/2 inch above Pin 2 and 15/16 inch above Pin 4. Start at the bottom hole, wind clockwise 2 1/4 turns, ending up at the hole over Pin 1. Now, in the same direction, wind 3 1/2 turns, spacing the turns out so that the winding will reach the top hole. Before soldering the ends of the wire to the pins, two *silvered* mica condensers are needed. (Silvered mica condensers hold their capacitance more constant with changes in temperature than those of the ordinary type. This helps to prevent "creeping" of the signal after it has been tuned in.) One of the condensers

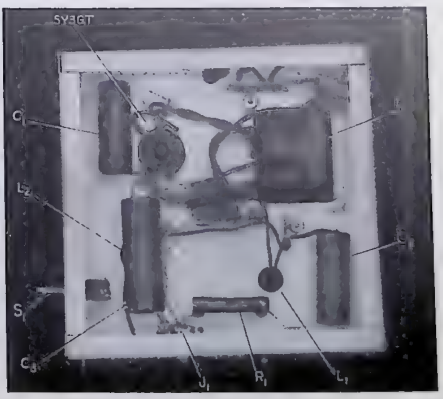


Fig. 28 — Bottom view of the superhet-receiver power supply.

should have a capacitance of 220-$\mu\mu$fd., while the other should be a 100-$\mu\mu$fd. unit. Place the two condensers with their flat sides together and solder the terminal wires together at each end, close to the condensers. This connects the two condensers in parallel so that the total capacitance is 320 $\mu\mu$fd. Cut off the excess lengths of terminal wire. Now solder a piece of the No. 22 wire about 6 inches long to each end of the condenser assembly. Remove the insulation, straighten the wires out and fish one of them through the inside of the coil form and down through Pin 2, along with the end of L_4. Fish the other wire similarly down through Pin 4. By pulling the wires carefully from the bottoms of the pins, draw the condensers as far down into the form as possible. (It doesn't matter if the condensers are tipped inside the coil form, so long as one end is close to the bottom.) Cut the wires close to the ends of the pins and solder each pin.

The input coil may be coated immediately with Duco cement or coil dope, but the oscillator coil must first be adjusted to the band. Plug the coils in and turn on the receiver. Turn C_1 and C_3 to maximum. Starting at minimum, tune C_2 carefully for the first point of maximum background noise. Set it at the point of maximum noise. Now with C_3 search the range for 20-meter 'phone or c.w. signals. If none are heard, push the turns of L_4 slightly closer together, or spread them slightly apart, until by trial the 20-meter band is found. When the band is located, place the high-frequency end at about 40 on the dial by very careful adjustment of the spacing of the turns. The winding can then be cemented in place. The tuning range now should extend approximately from 13,850 to 14,600 kc.

If C_2 is increased slightly, another point of maximum background noise will be found. This is the i.f. image response. With C_2 at this setting the range of approximately 10,850 to 11,600 kc. is covered. When the receiver is tuned for reception in the 20-meter band, any interfering images may be reduced by adjustment of the wavetrap.

The Wavetrap

In case an image signal or harmonic response from one of the bands not in use causes interference, it can be wiped out almost completely by accurately tuning C_2 for maximum response of the *desired* signal and tuning the wavetrap to the frequency of the *interfering* image. If you suspect that the interfering signal is an image, simply tune C_1 until the interfering signal becomes weaker or disappears altogether. If the *desired* signal and the interfering signal disappear together, the interfering signal isn't an image! If the *desired* signal becomes weaker without affecting the strength of the interfering signal, the wavetrap is tuned to the wrong frequency and a search should be made for the proper spot. The only thing to watch out for is that the trap isn't left tuned to the portion of the band where you want to listen. That is the reason for the preceding instructions regarding the preliminary setting of C_1 at minimum and maximum — to keep the trap tuned away from the band where you're listening.

A Simple 30-Watt Oscillator-Amplifier Transmitter

A transmitter of the oscillator-amplifier type is shown in Figs. 29, 33 and 34.

The circuit of such a transmitter is shown in Fig. 31. The oscillator circuit — that portion between R_1 and RFC_2 — is known as the Pierce circuit. It is one of the simplest crystal-oscillator circuits, since no tuning control is required. Although it is not feasible to couple an antenna to such a circuit, it works well when used to drive an amplifier. To explain the action of the circuit, we must go back to an earlier version shown in Fig. 30A. This circuit is known as the Colpitts

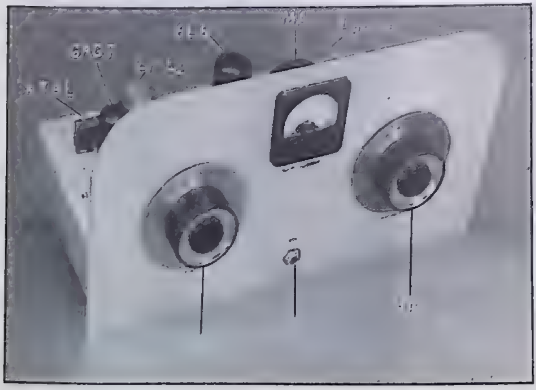


Fig. 29 — A two-tube crystal-controlled transmitter for the 80- and 40-meter bands. The panel is a sheet of 1/16-inch aluminum 7½ inches high and 14 inches long. The dials are National type HRT-O.

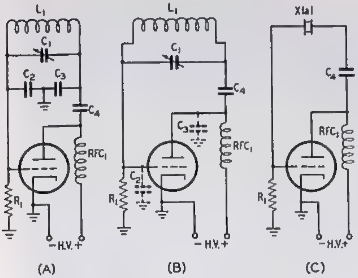


Fig. 30 — Development of Pierce oscillator circuit.

circuit. Oscillations can be obtained by proper connection of the tube to a tuned circuit, such as that consisting primarily of L_1 and C_1. To obtain oscillation, the plate is connected to one end of the tuned circuit and the grid to the other end. C_2 and C_3 form a capacitive tap across the circuit, just as if a tap were placed on the coil. The cathode is connected to this tap (through "ground"). Feedback is adjusted by changing the ratio of C_2 to C_3, just as it would be by a change in the ratio of turns on either side of a tap on the coil when the tap is moved. R_1 is the grid leak which provides the necessary operating grid bias. Voltage is fed to the plate through RFC_1 to prevent grounding of the plate through the power supply (parallel feed). C_4 keeps the d.c. plate voltage from being applied to the grid through the tank coil.

Fig. 30B shows a circuit called the ultraudion circuit. It is identical to the circuit of A except that the grid-to-cathode capacitance of the tube takes the place of C_2 and the plate-to-cathode capacitance serves for C_3.

Since a crystal is the equivalent of a tuned

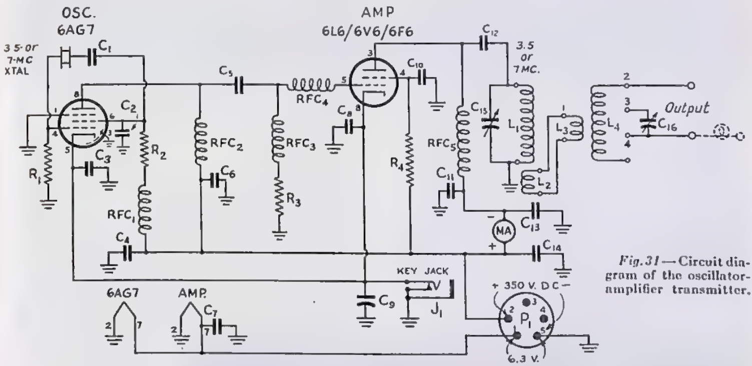


Fig. 31 — Circuit diagram of the oscillator-amplifier transmitter.

C_1 — Oscillator screen blocking condenser (takes d.c. off crystal) — 0.005-μfd. disk ceramic (Sprague 29C1).
C_2 — Feed-back adjusting condenser — 220-μμfd. mica.
C_3 — Oscillator cathode by-pass — same as C_1.
C_4 — Oscillator screen-circuit by-pass — same as C_1.
C_5 — Amplifier grid coupling condenser — 100-μμfd. mica.
C_6 — Oscillator plate by-pass — same as C_1.
C_7 — Heater r.f. by-pass — same as C_1.
C_8 — Amplifier cathode by-pass — same as C_1
C_9 — Key-click condenser — 8-μfd. 450-volt electrolytic.
C_{10} — Amplifier screen by-pass — same as C_1.
C_{11} — Amplifier plate by-pass — same as C_1.
C_{12} — Amplifier plate blocking condenser (prevents d.c. short circuit through L_1) — same as C_1.
C_{13}, C_{14} — Meter r.f. by-pass — same as C_1.
C_{15} — Amplifier output tuning condenser — 325-μμfd. variable (National STH-335).
C_{16} — Antenna tuning condenser — same as C_{15}.
R_1 — Oscillator grid leak — 56,000 ohms, ½ watt.
R_2 — Oscillator screen-voltage-dropping resistor — 22,000 ohms, 1 watt.
R_3 — Amplifier grid leak — 18,000 ohms, ½ watt.
R_4 — Amplifier screen-voltage-dropping resistor — 18,000 ohms, 2 watts.
L_1 — Amplifier output coil —
3.5 Mc. — 15 turns No. 22 wire, 1¾ inches diam., 1⅜ inches long. L_2 — 4-turn link (Bud OEL-40 with 4 turns removed from end opposite link or B & W JEL-40 with 5 turns removed).
7 Mc. — 14 turns No. 16 wire, 1¾ inches diam., 1¼ inches long. L_2 — 4 turn link (Bud OEL-20 or B & W JEL-20).
L_4 — Antenna tuning coil —
3.5 Mc. — 22 turns No. 22 wire, 1½ inches diam., 1¾ inches long overall, ½-inch space at center. L_3 — 6-turn variable link (Bud OLS-40 or B & W JVL-40).
7 Mc. — 12 turns No. 16 wire, 1½ inches diam., 1½ inches long overall, ½-inch space at center. L_3 — 5-turn variable link (Bud OLS-20 or B & W JVL-20).
J_1 — Key jack — closed-circuit.
MA — Amplifier plate-current milliammeter — 150- or 200-ma. scale.
P_1 — Five-pin chassis-mounting plug (Amphenol).
RFC_1 — Oscillator screen-feed choke — 2.5-mh. r.f. choke (National R100-S).
RFC_2 — Oscillator plate-circuit inductance — 100-μh. r.f. choke (Millen).
RFC_3 — Amplifier grid-feed choke — 2.5-mh. r.f. choke (National R100-S).
RFC_4 — V.h.f. parasitic-suppressor choke — 2-μh. r.f. choke (National R60).
RFC_5 — Amplifier plate-feed choke — 2.5-mh. r.f. choke (National R100-S).

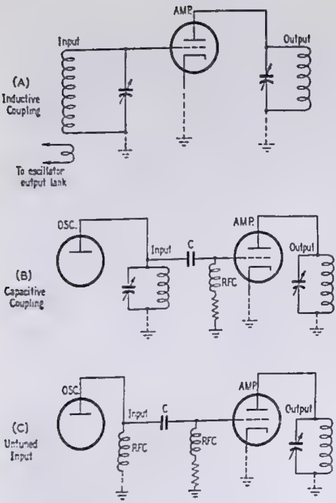


Fig. 32 — Development of amplifier arrangement.

circuit, we arrive at the circuit of Fig. 30C — the Pierce circuit which we are to use in the transmitter. In the latter, the *screen* of the 6AG7 is used as the plate of the oscillator circuit. Feedback is adjusted to the proper value by C_2 which is in parallel with the screen-to-cathode capacitance. R_2 is a series resistor to reduce the voltage for the screen.

The output of the oscillator is coupled to the 6AG7 output plate circuit principally through the electron stream within the tube. This is known as *electron coupling*. The r.f. output from the plate circuit appears across RFC_2. A tuned circuit could be used instead of RFC_2 with greater output from the oscillator, but this would mean an additional tuning control and a more complicated amplifier circuit.

The Amplifier

An r.f. power amplifier usually has two tuned tank circuits — the input tank circuit connected between grid and cathode and the output circuit between plate and cathode. The input tank circuit may be an independent one, as shown in Fig. 32A, or the output tank circuit of the oscillator may serve the same purpose, as shown at B. In the case of A, the output circuit of the oscillator is coupled to the input circuit of the amplifier by inductive means. The arrangement at B is called capacitive coupling, and C is the coupling condenser. Unless special precautions are taken the amplifier will oscillate when the input and output circuits are tuned to the same frequency. This is primarily because the two circuits are coupled through the plate-to-grid capacitance of the tube. We do not want the amplifier to operate as an oscillator; we want it to amplify the signal from the oscillator. To avoid the complications involved in other means, oscillation can be prevented by keeping either the input circuit or the output circuit tuned away from resonance. We want the greatest power possible from the output circuit. Therefore we make the grid circuit nonresonant. While this will result in less than maximum power output from the oscillator, we can afford to sacrifice efficiency at this point. Therefore, instead of the customary tuned tank circuit, we substitute an r.f. choke for the oscillator output tank circuit, as shown in Fig. 32C. Thus we arrive at the arrangement shown in Fig. 31 in which RFC_2 is the untuned circuit common to the output circuit of the oscillator and the input

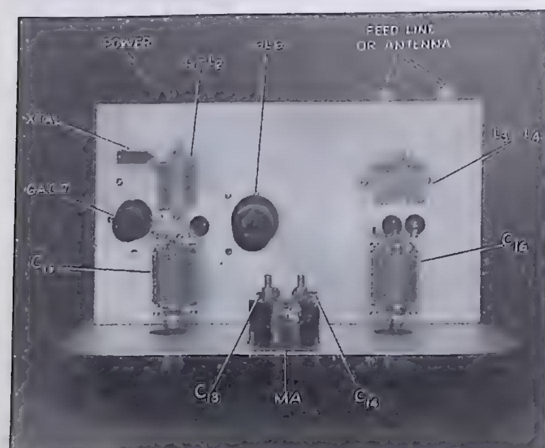


Fig. 33 — Top view of the oscillator-amplifier transmitter. The clearance holes for the wiring to the tuning condensers are lined with rubber grommets.

Forty-meter coils are used for 80, and 20-meter coils for 40 to obtain the desired tank-circuit Q.

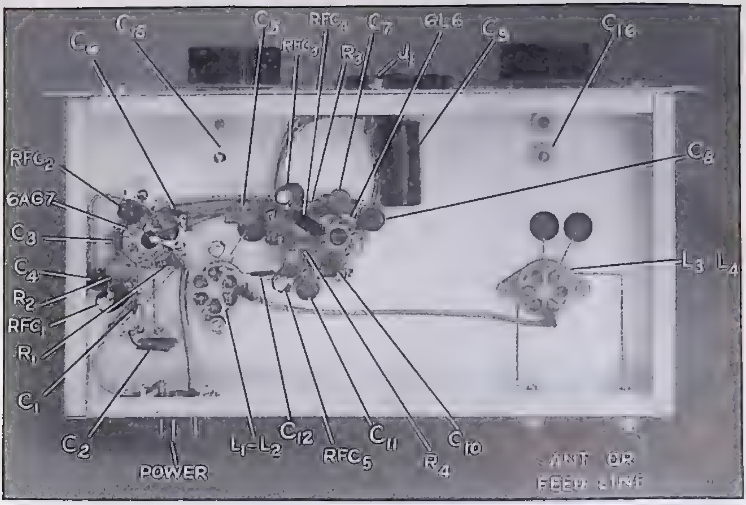


Fig. 34 — Bottom view of the two-tube low-power transmitter. The chassis measures 7 by 13 by 2 inches.

circuit of the amplifier, and C_5 is the coupling condenser. Here, a beam tetrode tube is used, instead of a triode, because the beam tube has greater *power amplification.*

R_3 is the amplifier grid leak. The impedance of RFC_3 in series with R_3 prevents r.f. currents from flowing through the grid leak and wasting power from the oscillator. C_{15} and L_1 make up the output tank circuit. Parallel feed is used to the amplifier plate through RFC_5, and C_{12} is the blocking condenser which passes r.f. but prevents short circuiting the d.c. plate supply through L_1. R_4 is a series resistor that reduces the voltage for the screen. C_3, C_4, C_6, C_7, C_8, C_{10}, C_{11}, C_{13} and C_{14} are all by-pass condensers designed to prevent the flow of r.f. (fundamental and harmonics) in the power-supply leads. The cathodes of the two tubes are connected together and the key jack is connected between the common cathode connection and negative h.v. which is connected to the chassis. This interrupts the plate-current flow to the tubes when the key is open. C_9 is for the purpose of reducing clicks on the transmitted signal which may cause unnecessary interference to amateurs operating near the same frequency as yours, as well as to nearby broadcast receivers.

Parasitic Oscillation

We know that as we go higher in frequency, the inductance and capacitance necessary to tune to resonance becomes smaller. In the regenerative receiver, for instance, the coils covering the higher frequencies are much smaller than those for the lower frequencies. If we go high enough in frequency, we come to the point where the inductance and capacitance of a short piece of connecting wire will be resonant. In most r.f. amplifiers, such small unavoidable factors combine to cause oscillation at frequencies in the neighborhood of 150 Mc. This must be avoided to prevent the wasting of power and to eliminate radiation at spurious frequencies. The small choke, RFC_4, which offers a high impedance to very-high frequencies, is inserted in series with the grid of the amplifier to prevent this type of oscillation.

Antenna Tuner

C_{16} and L_4 make up an antenna tuner. Its purpose is to provide means for resonating the antenna system and coupling it to the output circuit of the amplifier. The tuner is coupled to the amplifier tank by means of an inductive-link line as shown. The condenser may be connected in series with the coil or in parallel with it by proper connections between the pins on the plug-in base of L_4. Plate and filament power is fed to the transmitter through the chassis plug, P_1. The diagram of a suitable power supply is shown in Fig. 35. It is similar in circuit and principle to those discussed earlier. The single-section filter provides adequate smoothing for transmitting.

Construction

The general construction of the transmitter is designed to match that of the superhet receiver. Therefore the chassis and panel dimensions are the same and the unit will fit into a similar cabinet. As in the receiver, the exact placement of parts on top of the chassis is not critical. The two variable condensers, C_{15} and C_{16}, are placed at either end of the chassis to balance (shafts about 3 inches in from the ends). C_{16} must be insulated

Fig. 35 — A power supply for the oscillator-amplifier transmitter. It is built on a 7 × 7 × 2-inch aluminum chassis following suggestions laid out for the superhet receiver supply. The output socket is placed to match up with the plug in the rear of the transmitter chassis.

from the chassis, so it is mounted on Millen 32100 feed-through insulators which require ⅜-inch holes. C_{15} need not be insulated, but metal spacers are used to bring its shaft up level with that of C_{16}. The respective coil sockets are mounted directly behind the condensers, with their axes at right angles to minimize direct inductive coupling.

The sockets (Millen) for the crystal and the oscillator tube are placed in the space at the left-hand end of the chassis and the amplifier tube an inch or two to the right of C_{15} and L_1. The Millen ceramic sockets require 1¼-inch holes. The oscillator socket is mounted with its key toward the front, while the key of the amplifier socket is toward the right. The amplifier-coil socket (5-prong) is turned so that the large Pins 1 and 5 are toward the right. The link prongs of the antenna-coil socket (5-prong) are to the rear. Two solder lugs should be placed under each socket-mounting nut for ground connections.

Clearance holes are drilled at the rear of the tuning condensers for the connecting wires. A hole is also required near the front of the chassis at the center for the wires running to the meter if one is to be used. A hole for the key jack is needed in the front edge of the chassis at the center. In the rear edge the power plug is mounted at the left-hand end and the two output terminals, which are a pair of ⅜-inch feed-through insulators similar to those mounting C_{16}, are at the opposite end.

RFC_1, RFC_3 and RFC_5 are mounted with a single screw in the locations near the tube sockets shown in Fig. 34. A fiber lug strip is fastened under RFC_5 to provide an insulating anchorage for the bottom end of R_4. A ¾-inch ceramic cone insulator is fastened to the right-hand mounting screw of the 6AG7 socket (in bottom view), and another similar insulator is fastened to the chassis immediately above the socket. Two soldering lugs are fastened to the top of each insulator.

Wiring

As pointed out in the discussion of the oscillator in the superhet receiver, oscillators (and amplifiers too) can generate harmonics. Experience has shown that even a low-power transmitter operating at 80 or 40 meters can cause interference to television receivers in the immediate neighborhood if one or more of the higher order of harmonics falls in a television channel — even though the power generated at such a high frequency is, of course, very small indeed. Therefore, at least the most essential steps should be taken to reduce harmonics in the power-supply leads and the antenna. This consists of the use of shielded power wiring, low-inductance by-pass condensers with short leads, and the link-coupled antenna tuner. Under some circumstances it may be necessary to take further measures to suppress TVI, but those mentioned should suffice in most cases. In particular, it may be necessary to shield the transmitter by placing it in a metal cabinet. If this is done, the panel furnished with the cabinet will be used, rather than the one described, of course.

Shielded wire consists of an insulated conductor covered with copper braid. In using it, care must be exercised in keeping the ends of the copper braid away from contact with the inner conductor. In preparing the end of the wire, wrap three or four turns of No. 22 bare tinned wire (or cotton- or silk-covered magnet wire with the insulation removed will do) tightly around the shielding braid at about one inch from the end, leaving a lead of 2 or 3 inches at one end of the binding wire. Then fray the braid back to the binding and trim the braid off close with cutting pliers or shears. Flow solder around the turns of bare wire. Then remove the insulation from the end of the conductor for a distance of about ½ inch. This should leave about ½ inch of insulation

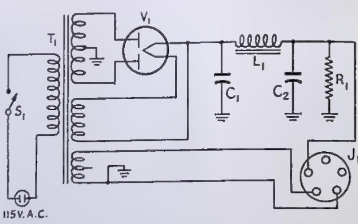


Fig. 36 — Wiring diagram of the power supply for the oscillator-amplifier transmitter.

C_1 — Filter input condenser — 8-μfd. 500-volt electrolytic.
C_2 — Filter output condenser — 8-μfd. 450-volt electrolytic.
R_1 — Bleeder resistor (discharges condensers when power is turned off) — 50,000 ohms, 10 watts.
L_1 — Filter choke — 10.5 h., 110 ma. (Stancor C1001).
J_1 — Five-prong chassis-mounting socket (Amphenol).
S_1 — Power switch — s.p.s.t. toggle.
T_1 — Power transformer — 360–0–360 volts r.m.s., 120-ma.; 5 volts, 3 amps.; 6.3 volts, 4.5 amps. (Stancor PC8410).
V_1 — Rectifier tube — Type 80 or 5Z3.

between the conductor wire and the braid. Both ends of each piece of shielded wire should be prepared in the same way. The loose lead fastened to the shielding should be grounded to the chassis after the wire is installed.

Pins 1 and 2 of the amplifier-tube socket, Pins 1, 2 and 3 of the oscillator-tube socket, and Pin 4 of the amplifier-coil socket are connected directly to ground at one of the adjacent grounding lugs. Pin 5 of the power plug also is connected to the chassis. Then a short length of shielded wire is run from Pin 1 on the power plug to Pin 7 on the 6AG7 socket, and another section of shielded lead from there to Pin 7 on the amplifier-tube socket. Another section of shielded wire is run from Pin 2 on the power plug to the bottom terminal of RFC_1, another piece from there to the lug on top of the cone insulator holding RFC_2, another from this point to connect to R_4, and the last piece goes up through the chassis to connect the latter point to the positive terminal of the milliammeter. Another section of shielded wire runs from the negative terminal of the milliammeter back down to the bottom end of RFC_5. If a meter is not used, a connection is made directly from the fiber lug-strip termination of R_4 to the bottom end of RFC_5. The two cathode terminals of the tube sockets are connected together with shielded wire and another piece of shielded wire is run from Pin 8 on the amplifier-tube socket to the key jack. When the shielded wiring is completed, those wires running parallel, or crossing, should be spot-soldered together at intervals.

The various small by-pass condensers are installed next, soldering them directly between the tube-socket or r.f.-choke terminals and the nearest grounding lug with the shortest possible leads. R_1 is placed directly between Terminal 4 of the 6AG7 socket and ground, and R_3 between the bottom end of RFC_3 and ground. R_2 is connected between the top end of RFC_1 and Pin 6 of the 6AG7 socket. R_4 is wired directly between Pin 4 of the amplifier-tube socket and the fiber lug strip. C_9 is connected between Pin 8 of the amplifier-tube socket and the grounded terminal of the key jack. A section of 75-ohm Twin-Lead or parallel-conductor lamp cord connects the link terminals of the coil sockets.

The top terminal of RFC_5 is wired to Pin 3 of the amplifier-tube socket and C_{12} is connected between the top of the same choke and Pin 2 of the amplifier-coil socket. RFC_4 is connected directly between the top terminal of RFC_3 and Pin 5 of the amplifier-tube socket.

The r.f. wiring, of which there is very little, should be done with stiff wire, No. 16 or larger. It should be kept well spaced from the chassis and other components. One wire connects one side of the crystal socket to Pin 4 of the 6AG7 socket. Another is run from the second crystal-socket terminal to Pin 6. After the wire is soldered in place, a ½-inch section is cut out of the center and C_1 is inserted.

A wire connects Pin 2 of the amplifier-coil socket to the rear stator terminal of C_{15}. C_8 is soldered between the top of RFC_3 and the anchoring lug on top of the second cone insulator near the 6AG7 socket. A short piece of wire runs from there to Pin 8 of the 6AG7 socket.

The antenna-coil socket is wired according to the pin numbering in Fig. 31.

The panel is fastened to the chassis with two machine screws at each end. A hole is required to match the hole in the chassis for the key jack. The 1¼-inch socket punch is used to make clearance holes in the panel for the shafts of the two tuning condensers. The hole for the meter can be cut with a circle cutter in a carpenter's brace. The size of the hole will depend upon the dimensions of the meter used, of course. The meter shown is of the 2-inch variety, but panel space is available for a 3-inch meter. After the meter wires have been connected, C_{13} and C_{14} should be added. They are connected directly between each meter terminal and the shielding braid of the meter wires. The braid of each meter wire is then

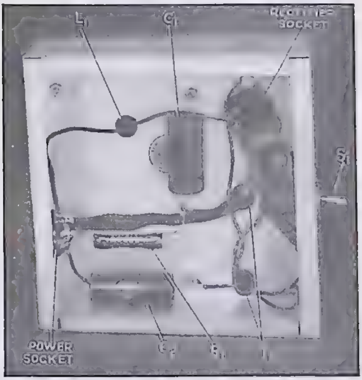


Fig. 37 — Bottom view of the oscillator-amplifier transmitter power supply.

grounded to one of the meter-mounting screws. Since the meter terminals are exposed high-voltage points, they should be covered with sleeves of rubber tubing to remove the hazard.

Power Supply

The transmitter power supply shown in Figs. 35 and 37 will deliver 350 volts under a full load of 110 ma. Any other power supply delivering up to a maximum of 350 to 375 volts under load will do. Naturally, if the voltage applied to the transmitter is lower, the power output will be reduced correspondingly. The circuit diagram is shown in Fig. 36. The principles are similar to those discussed in connection with the power supply for the simple oscillator transmitter and the construction parallels that of the supply for the superhet receiver. Since the transformer is not of the flush-mounting type, no cut-out in the chassis is required; only two holes for the leads are needed.

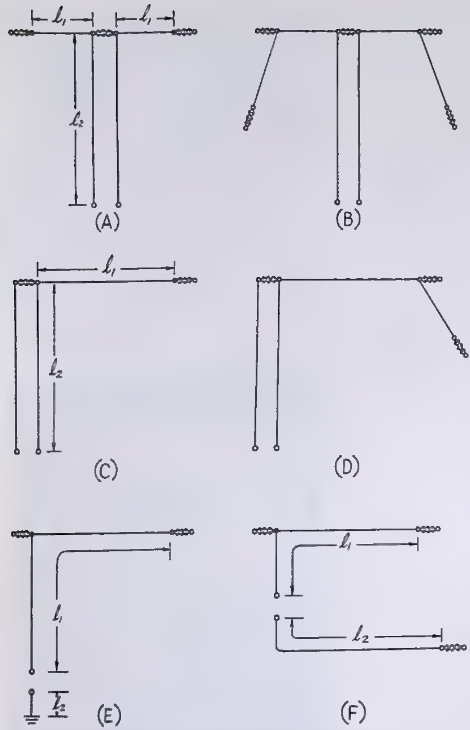


Fig. 38 — Various types of antennas recommended for use with the beginner's transmitter for 40 and 80 meters. See table for dimensions.

Choosing Crystal Frequencies

Following current amateur practice, an operator, after he has called CQ, listens first on or quite near his own transmitter frequency. Therefore, it follows that you will stand a better chance of raising him if your transmitter frequency is as close as possible to his. In other words, you will usually be more successful in making contacts if you call stations working on frequencies close to your own transmitter frequency. Also, when you call CQ, you will usually find that most of the stations answering you will be close to your transmitter frequency. For this reason it is an advantage to have several crystals at different frequencies.

Although c.w. operation is permitted on any frequency in the bands assigned to amateurs, you will seldom find any c.w. operation in the bands assigned to 'phone.

The holder of a Novice Class license *must* choose crystal frequencies between 3700 and 3750 kc. for 80-meter operation, for 40-meter operation, the operating frequencies must lie between 7175 and 7200 kc. These frequencies can be obtained either by using crystals of these frequencies, or by doubling frequency using crystals between 3587.5 and 3600 kc.

To avoid the 'phone bands, a holder of a General Class or Extra Class license should choose frequencies between 3500 and 3800 kc. for 80-meter work. When operating in the 40-meter band, the crystal frequencies should lie between 7000 and 7200 kc., or between 3500 and 3600 kc. if frequency is doubled.

Antennas

A single antenna can be made to serve for both 40 and 80 meters. It may take any one of several forms. Where space is available, the preferable antenna consists primarily of a horizontal wire one half wavelength long for 80 meters (approximately 135 feet) running in a straight line and elevated as high as possible. An antenna of this type is connected to the transmitter through a *transmission line* or *feeder line*, which is simply a pair of parallel wires spaced 2 to 6 inches. The feed line may be attached to the antenna at one end, as shown in Fig. 38C but, wherever it is at all feasible, it should be connected at the center, as shown in Fig. 38A. Where a choice in direction exists, the center-fed antenna should be in a line at right angles to the direction in which it is most desired to work, while the end-fed antenna should be in a direction approximately 45 degrees from the most-desired path.

Antenna Data Table

	l_1	l_2	*80 M.*	*40 M.*
Figs. 3A and 3B	67 ft.	67 ft.	par.	par.
	33 ft.	33 ft.	ser.	par.
	$l_1 + l_2$ = 134 ft. (l_1 long as possible)		par.	par.
	$l_1 + l_2$ = 67 ft. (l_1 long as possible)		ser.	par.
Figs. 3C and 3D	134 ft.	67 ft.	ser.	par.
Fig. 3E	$l_1 + l_2$ = 67 ft. (l_2 short as possible		ser.	par.
Fig. 3F	67 ft.	67 ft.	ser.	par.

If space does not permit running the antenna in a straight line, it may be bent to accommodate the length, or the ends may be dropped down, as shown in Figs. 38B and 38D. The angles at the bends should be as wide as possible. Although such bending will have some influence on the performance of the antenna, it will still work quite well. The center-fed antenna is much more tolerant as to dimensions than one which is end fed. In restricted space, the horizontal antenna portion may be made as long as space permits and the deficiency in length added to the feed line, keeping the over-all length the same. It is not advisable to do this with the end-fed antenna.

When a feed line is used, power from the transmitter can be fed more readily to the antenna if the feed line is cut to certain lengths. These lengths together with other essential dimensions of various recommended systems are shown in the accompanying table.

Another type of antenna is known as the Marconi antenna. This consists of a wire whose total length is one quarter wavelength instead of one half wavelength. For 80 meters this means a length of about 67 feet. This antenna is shown in Fig. 38E. When such an antenna is used, the remaining output terminal of the transmitter must be connected to a ground (such as a water pipe) or to another quarter wavelength of wire which may be suspended a few feet above the ground, as shown in Fig. 38F. It is not essential that the lower wire run exactly under the antenna.

The table of antenna dimensions also shows whether series or parallel tuning should be used, that is, whether C_{16} should be connected across L_4 or in series with it and the feed line.

The antenna may be strung between any existing supports, such as trees or buildings, or some type of mast may be used. When a feed line is used, the antenna may be of No. 12 or No. 14 antenna wire, while the feed line may be made of No. 16 wire to minimize the weight. Plastic spreaders are recommended for spacing the feeder wires because of their light weight. They can be obtained in several different lengths. When the feed line is long, the wider spacing will give less trouble from twisting. Fairly-strong glass or porcelain insulators should be used for the antenna, especially if the antenna is to be strung between trees.

Adjustment

Aside from the 6L6, a 6V6 or 6F6 may be used in the amplifier without circuit change. The smaller tubes will not handle as much power as the 6L6, of course.

The power supply should be connected to the transmitter. The 80-meter coil should be plugged into the amplifier circuit and an 80-meter crystal placed in the crystal socket. The antenna-coil socket should be empty. With the power turned on, and the key plugged in and closed, the milliammeter should show a reading (80 to 125 ma. with a 6L6 and 350-volt supply). Starting at maximum capacitance, C_{15} should be adjusted carefully until the plate current dips to a minimum. This indicates resonance at the crystal frequency. A further decrease in condenser capacitance should reveal another slighter dip in plate current. This indicates resonance at the second harmonic or twice the crystal frequency. This setting should be avoided in operating the transmitter.

The 80-meter antenna-coil plug should now be connected up for either series or parallel tuning as indicated in the table. The coil center-tap wire should be disconnected from Pin 3. For series tuning the coil end going to Pin 4 should be shifted to Pin 3. If parallel tuning is required, Pins 2 and 3 should be connected together.

Now connect one of the feed-line wires to one transmitter output terminal. Connect the other feed-line wire to one terminal of a dial-lamp socket and the other dial-lamp terminal to the remaining output terminal, as indicated in Fig. 31. If series tuning is required, use a No. 41 (white bead) 2.5-volt 0.5-ampere lamp in the socket. If parallel tuning is specified, use a No. 48 (pink bead) lamp rated at 0.06 ampere.

Set C_{16} at minimum capacitance, close the key and retune the amplifier to resonance at 80 meters. The dip in plate current probably will not be so pronounced as it was before the antenna coil was plugged in. Then adjust C_{16} and watch the plate current. At some point in the range of C_{16}, the plate current should rise to a maximum. Adjust C_{16} to this maximum. At this point the lamp in the feed line should show an indication of output. If it doesn't show at least a glow when series tuning is used, try a lamp with a lower current rating, such as the No. 46 (blue bead) which has a rating of 0.25 ampere. If, on the other hand, the lamp burns out with parallel tuning, use a lamp with a higher current rating, such as the No. 40 (brown bead) rated at 0.15 ampere.

Now readjust C_{15} for maximum lamp brilliance. A slight further readjustment of C_{16} and then C_{15} may improve the output. At this point, detuning C_{15} in either direction should show at least a slight rise in plate current. If it doesn't, the coupling should be reduced by bending the adjustable link away from the antenna coil. Use the tightest coupling that will permit a discernible dip in plate current when C_{15} is tuned through resonance. When tuning is completed, the dial lamp may be shorted out with a clip lead.

Forty-meter output can also be obtained with an 80-meter crystal, simply by plugging in the 40-meter coils and following the same procedure. However, the output in this band will be greater if a 40-meter crystal is used. Be sure to note from the table if there is a change between series and parallel tuning in going from 80 to 40 meters and wire up the 40-meter antenna-coil plug and change the dial lamp accordingly, if required.

Depending upon the output voltage of the power supply, it should be possible to load the 6L6 up to a plate current of 90 ma. Plate current to a 6F6 or 6V6 should be limited to 50 ma.

A 2-Meter Station for the Novice

Operation on the v.h.f. bands has always had a special appeal for the experimentally-inclined amateur, whether he is a newcomer to the game or an old-timer with years of experience on lower bands. Up to the last few years this appeal has been based at least partly on the simplicity of the equipment used in v.h.f. work, but increased occupancy and resulting advanced techniques have tended to lift v.h.f. gear out of the ultrasimple category.

At the same time, however, better utilization of our v.h.f. assignments has opened up new opportunities for interesting work in this field. Once thought of as useful only for communication over purely line-of-sight paths, the 144-Mc. band has been the scene of constantly-expanding horizons. Today many of our better-equipped stations work consistently over distances of 100 miles or more, with contacts up to several times that distance being made when conditions are good. It is probable that we have done little more than scratch the surface of the opportunities open to the enterprising v.h.f. amateur, and the fellow who takes his 2-meter work seriously has a good chance to make real contributions to the record of amateur radio development.

We have a way of thinking that things that are new are necessarily difficult. To combat the idea that getting started on 144 Mc. is complicated or expensive a complete 2-meter station, beginner style, is presented herewith. It is not the simplest or least expensive 2-meter gear that could be built; rather it was laid out with the idea of meeting the following objectives:

1) Practical straightforward design, without trick circuits or difficult adjustments.

2) Lasting usefulness, through adaptability to higher power or improved performance as the beginner's interest and skill develop.

3) Sufficiently good performance to permit the user to do interesting work on 144 Mc.

Low cost and a minimum of components were kept in mind, but they were secondary to the above considerations. The station is composed of four main pieces of equipment, as may be seen in the composite photograph. There is a transmitter r.f. section, shown in the upper deck of the rack; a modulator unit, including provision for keyed tone, seen at the left; a converter, to provide 144-Mc. coverage when used with any receiver that tunes to 7.4 or 10.7 Mc., at the right; and a power supply capable of handling the transmitting and receiving units. This is in the lower portion of the rack.

The Converter

Though it is, of course, possible to receive 2-meter signals with a one- or two-tube superregenerative receiver, the converter described herewith may be built with little more effort. Even when it is used with an inexpensive all-wave receiver the performance will be much better than is possible with the superregen. It may be used with the 4-tube receiver described earlier with good results.

Only two tubes are used — a 6J6 dual-triode mixer-oscillator, followed by a 6AK5 amplifier stage. The first half of the 6J6 is the mixer, its grid circuit being tuned to the signal frequency by L_2 and C_1, and its plate circuit to the intermediate frequency by L_4 and C_6. The oscillator is tuned by means of C_4, C_5 and L_3, in the plate circuit of the second half of the 6J6. The vernier dial, attached to C_4, is the only control used in the course of normal operation of the converter.

The 6AK5 amplifier stage adds somewhat to

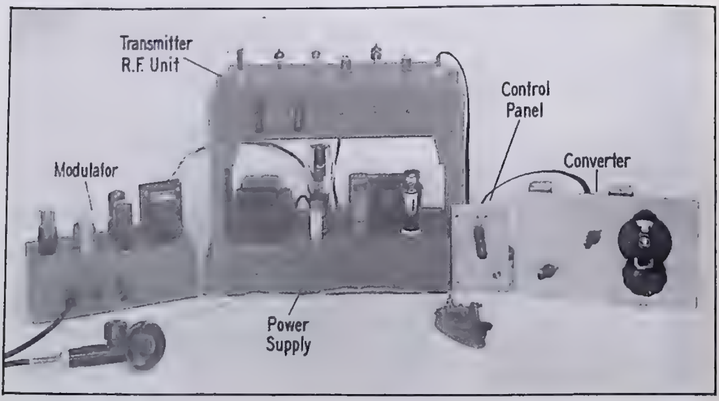


Fig. 39 — A complete two-meter station for the beginner.

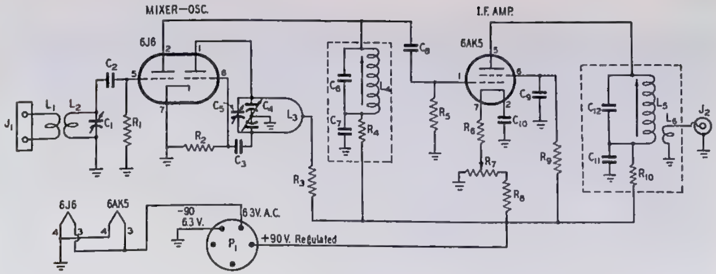


Fig. 40 — Wiring diagram of the simple 2-meter converter.

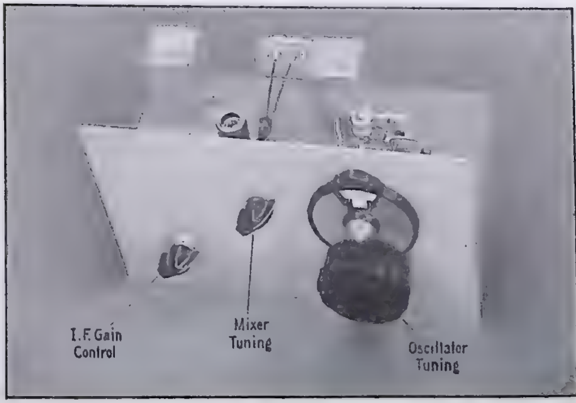
C_1 — 15-μμfd. midget variable (Millen 20015).
C_2 — 100-μμfd. mica or ceramic.
C_3, C_8 — 50-μμfd. mica or ceramic.
C_4 — Special split-stator variable, 7 plates per section, made from Millen 21935 — see text.
C_5 — 30-μμfd. air-dielectric padder (Silver 619). Alternative: Ceramic trimmer of similar capacitance, such as Centralab 820-C.
C_6, C_{12} — 33-μμfd. mica or ceramic. This value is for a 10.7-Mc. i.f. If 7.4 Mc. is used, increase to 50 μμfd.
C_7, C_9, C_{10}, C_{11} — 0.005-μfd. disc-type ceramic (Sprague 29C-1).
R_1, R_5 — 1 megohm, ½ watt.
R_2 — 10,000 ohms, ½ watt.
R_3 — 10,000 ohms, 1 watt.
R_4, R_9, R_{10} — 1000 ohms, ½ watt.
R_6 — 220 ohms, ½ watt.
R_7 — 2000-ohm wire-wound potentiometer.
R_8 — 22,000 ohms, 1 watt.
L_1 — 2 turns No. 14 enamel, ⅝-inch diameter, close-wound, with 2¾-inch leads. Insert between turns of L_2.
L_2 — Same as L_1, but turns spaced ¼ inch. Mount directly on C_1, with shortest possible leads.
L_3 — Loop No. 12 tinned wire, 1 inch long and ½ inch wide. Solder directly to stator bars — see photo.
L_4, L_5 — 7.4 Mc.: 22 turns No. 22 d.s.c., close-wound on National XR-50 slug-tuned form. 10.7 Mc.: 20 turns.
L_6 — 3 turns No. 22 d.s.c., close-wound at cold end of L_5.
J_1 — Antenna terminal (Millen 33102 crystal socket).
J_2 — I.f. output terminal (Jones J-201). Coaxial fitting for the cable, not shown, is Jones P-201
P_1 — 5-prong plug (Amphenol 86-CP5). Matching cable fitting is Amphenol 86-PM5.

the complexity of the converter, but it makes such an improvement in its performance that it is well worth the added work and cost. This is particularly true if the receiver with which the converter is to be used is one of the lower-priced models having somewhat low sensitivity. If one is fortunate enough to have a high-grade communications receiver the i.f. stage may be omitted from the converter with only a slight loss in effectiveness, but even with such receivers the gain-control feature inherent in the amplifier stage is very useful.

Mechanical Details

A good rule to follow in laying out any kind of radio gear is to start with a somewhat larger chassis and panel than you think you'll need. With plenty of room to work in a neater job can be done, and the equipment will be easy to service, should trouble develop later on. This principle was followed throughout the design of this 2-meter station. It could have been built in a fraction of the space, but the open construction used results in a clean uncluttered look and

Fig. 41 — Front view of the 2-meter converter. The oscillator tuning (vernier dial) is the only adjustment used in normal operation. The shields at the back of the chassis house the mixer and i.f. amplifier plate-coil assemblies.



makes the details easier to follow. Closely-packed designs are required in some instances, but they are an invitation to trouble, especially for the beginner.

All parts are standard components, readily obtainable in most localities, and detailed layout drawings are provided so that the constructor may make an exact duplicate if he so desires. In some instances, however, the dimensions are not particularly critical, and other parts of similar characteristics may be substituted, even though some variation in layout may be required. Points where dimensions are important will be emphasized in the text. The layout drawings, Fig. 42, show the positions of the holes in the front panel, the top of the chassis, and the rear of the chassis, in the order that they would be seen in picking up the unit and rotating it about its long axis.

Looking at the front-view photograph, we see the vernier dial (National BM) at the right. Notice that a large knob (National HRK) has

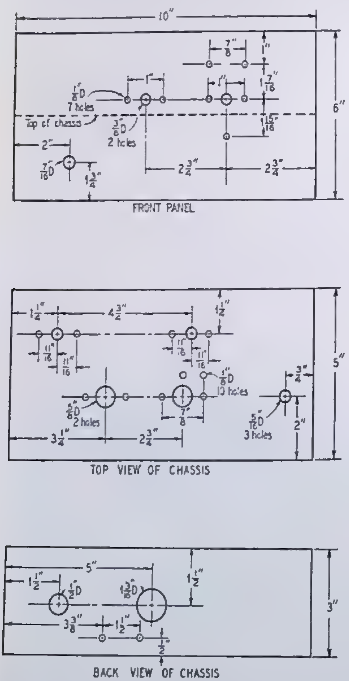


Fig. 42—Layout drawing of the front panel and chassis used in the 2-meter converter. If the constructor has duplicates of the parts used in the original model these dimensions may be followed to produce an exact duplicate. Views show the panel and chassis as they appear when the unit is picked up and rotated about its long axis.

been substituted for the small one normally supplied with the dial. This helps to smooth out the tuning, a feature that will be appreciated when the receiver is used for extended operating periods. Also mounted on the front panel are the mixer tuning condenser, C_1, and the potentiometer, R_7. These are normally adjusted to the proper setting when the converter is placed in service and seldom used thereafter.

Looking at the rear of the unit, we see the 6J6 socket, mounted bottom up, so that the tube projects below the chassis. It is important that this part of the layout be followed closely, as the length of leads in the mixer and oscillator circuits are quite critical.

On the back wall of the chassis are the antenna terminals (a standard crystal socket), the power plug, and the coaxial fitting for the i.f. output. Note that removable plug fittings are used for the cabling between units. Some economy could be effected by wiring the units together, but the detachable fittings add greatly to the ease of setting up or dismantling the station. If the gear is to be used in various locations such as in Field Day operation, this feature will be very helpful.

The oscillator tuning condenser, C_4, requires some revision. It is made from a Millen 21935 double-spaced variable, originally a single-section type. The two bars on which the stationary plates are mounted are sawed through at points just inside the fifth stator plate from each end. The three rotor plates at the middle and two at each end of the rotor assembly are pulled out, and the end plate on each stator assembly is removed. This leaves a split-stator condenser having three rotor plates and four stator plates in each section. By suitably modifying the layout, other split-stator variable condensers may be used. One recommended type is the National VHF-1-D.

The tank inductance, L_3, is soldered directly to the stator bars, as is the air-dielectric padder condenser, C_5. The use of a stable type of trimmer is important in the latter position. If the air padder used in the original model is not available, one of the ceramic-type variables should be substituted. Do not use a mica-dielectric padder. Both the panel-mounted variables are spaced away from the panel by mounting sleeves a half inch long. The holes in the panel should be large anough so that the rotor shafts do not touch the panel. The ground connection to the rotor is made by soldering a short piece of wire from the rotor spider to the mounting stud just below it. It is important that all parts of the oscillator circuit be completely rigid, as the smallest movement will cause a variation in oscillator frequency. Mechanical stability in the oscillator tank circuit is aided by making the dropping resistor, R_3, serve as support for the tank inductance. The power lead is brought through the chassis on a feed-through bushing to which the dropping resistor is attached.

The 6J6 socket is mounted with the heater terminals, Pins 3 and 4, toward the oscillator tuning condenser. Fixed condensers C_2 and C_3 and resistors R_1 and R_2 are wired into position

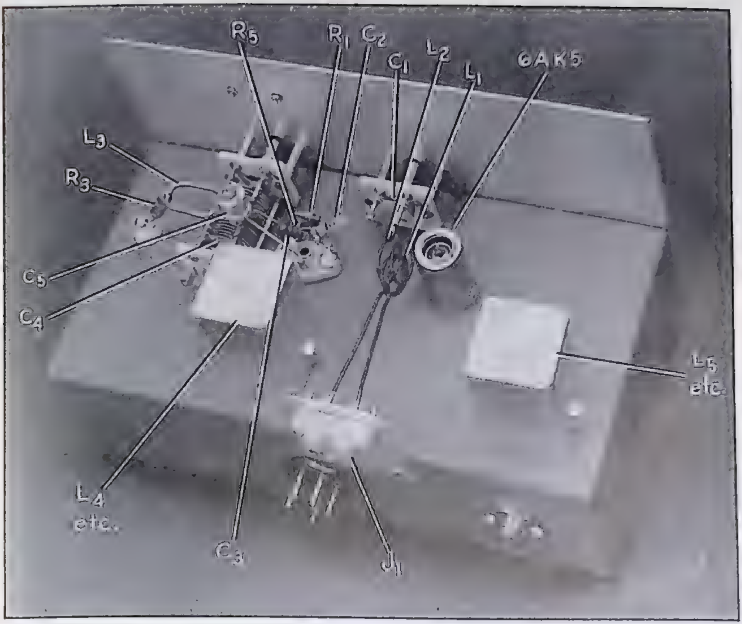


Fig. 43 — Rear view of the converter, showing the position of all the components above the chassis. The leads visible in this view are critical as to length, and the layout shown should be followed closely for best results.

with the shortest possible leads. The heater lead and the lead to C_8 are run through two holes drilled in the chassis adjacent to the socket terminals. The lead to the mixer plate coil, L_4, is run through a hole drilled in the side of the shield can.

The coil shields are Millen 80003, originally four inches long, cut down 2¼ inches. Shorter shields may be obtainable, eliminating the cutting operation. The spade lugs can be drilled out of the cut-off part and used for mounting the shields to the chassis. The plate coils, L_4 and L_5, have their core-adjusting screws projecting through the chassis. Leads to the windings are brought through chassis holes, except for the mixer plate lead, which is run through the side of the shield, as explained above. The forms have only two terminals and a ground lug, so the top end of L_6 must be held in place with a drop of household cement. The turns of L_6 may be wound over L_5 and the ends of the wire wrapped around the other terminals temporarily while the cement is drying.

Wiring may be done with insulated wire of the push-back variety, or bare wire of about size 20 may be used, slipping spaghetti over the wires for insulation where it is needed. Use of tie-points at junctions of several wires makes for neat and rugged assembly. Three of these were used in the converter: a two-terminal strip mounted on one of the screws of the first i.f. shield, as a junction for the plate-voltage leads; and two single-terminal plates, one on the 6J6 socket and the other on one of the mounting screws for the second i.f. shield.

Adjustment and Operation

Before any attempt is made to operate the converter it is advisable to check through the wiring carefully to see that no mistakes have been made and no connections omitted. Any power supply delivering 90 to 150 volts d.c. and 6.3 volts a.c. may be used for testing the converter. The power supply to be described later includes provision for the converter, but the initial tests may be carried out with any supply capable of delivering the above voltages. Two 45-volt B batteries may even be used for plate supply.

Apply the heater voltage, 6.3 volts a.c. first, making sure that the tubes light up. The 6J6 will show its heater plainly when it warms up. The 6AK5 heater will not be so easily discernible, as it is almost completely shielded by the other elements of the tube. It will become noticeably warm to the touch, however, if the heater is drawing the proper current.

Next we check the operation of the oscillator. A meter (anything from 0–25 to 0–100 ma. will do) will be handy, though not absolutely necessary here. Connect the meter between the bottom of R_3 and the B-plus source and note the current being drawn. If the tube is oscillating the current will probably be between 5 and 10 ma., and it will rise if the oscillator inductance, L_3, is touched with a pencil lead. To check the frequency of the oscillator you will need some sort of absorption-type wavemeter or other indicating device. A Millen 90609 or 91610 will be fine for this purpose, or you can make one of your own out of any small variable condenser and a few turns of wire. The frequency of any r.f. power source in the v.h.f. range can be measured by means of Lecher wires, the construction and use of which are explained in all recent editions of the *Radio Amateur's Handbook*. The beginner in the v.h.f. field will do well to familiarize himself with Lecher-wire technique, as he will find frequent use for it. Calibration of a homemade wavemeter is one example.

When used for checking frequency either Lecher wires or an absorption-type wavemeter will cause a rise in plate current when tuned to the oscillator frequency. If a power supply with a gaseous regulator tube is used the glow in the tube will be seen to change as the wavemeter is tuned across the oscillator frequency. This is one way of checking frequency if no plate meter is available. The wavemeter or Lecher-wire coupling should be as far away from the oscillator circuit as possible and still cause a visible indication, for most accurate measurement.

The oscillator is adjusted to the proper tuning range by means of the padder condenser, C_5. This will be lower than the signal frequency by the value used for an intermediate frequency. Use of 10.7 Mc. is suggested, as this is the RMA standard for converter service. Some communications receivers tune the amateur bands only, however, so provision is made in this converter design for using an i.f. at the high end of the 7-Mc. band, preferably 7.3 to 7.4 Mc. Values of L_4, L_5, C_6 and C_{12} are given in the parts list for both frequencies. The range of C_5 is more than adequate to take care of either frequency. The complete tuning range of the oscillator should be about 6 megacycles, to allow some leeway at each end of the band. For a 10.7-Mc. i.f. this will mean that the oscillator should tune approximately 132.3 to 138.3 Mc. With a 7.4-Mc. i.f. the oscillator range should be about 135.6 to 141.6 Mc.

Now connect the coaxial cable from the converter output to the antenna terminals of the receiver with which the converter is to be used and set the receiver dial at the frequency to be used for the i.f. Turn the converter gain control toward maximum position. If everything is working correctly there should be some increase in receiver noise as the gain is advanced, even though the i.f. coils have not been peaked.

Setting these coils to the proper inductance is the next step. A signal generator is helpful for this but it is not necessary, as it may be done by merely turning the core screws to the point of maximum receiver noise. If this occurs with the

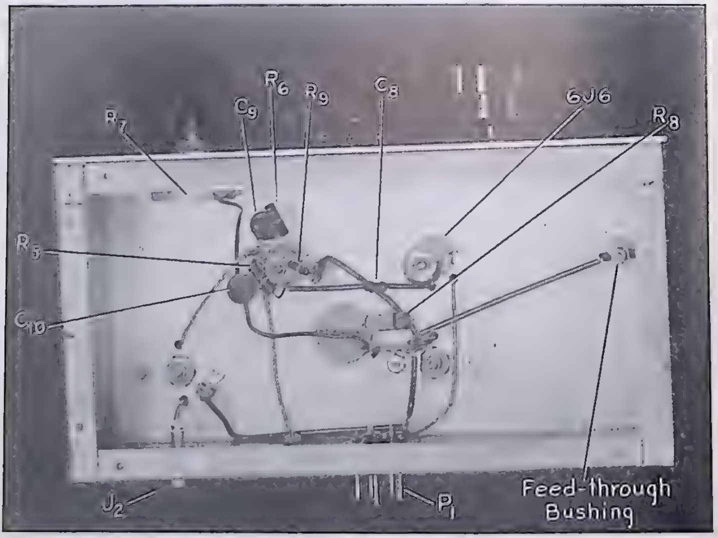


Fig. 44 — Bottom view, showing the components that are less critical as to placement and lead length.

core screw at the all-in or all-out position, the inductance of the coil is too low or too high, respectively. This may be corrected by increasing or decreasing the number of turns on the main winding, or by increasing or decreasing the value of the fixed condenser connected across it. The actual frequency used is not important, so it may be shifted one way or the other to compensate for variations in coil inductance or padder capacitance, if desired.

When the mixer and i.f. amplifier plate coils have been tuned to the proper frequency we are ready to receive signals, the only further adjustment being the peaking of the mixer grid-circuit trimmer, C_1. This is not critical, however, and a fairly strong signal will be heard regardless of where this control is set. Best results will be obtained if this is peaked for maximum response on a signal near the middle of the band, after which it will not usually be necessary to readjust it. The peaking should be done with the antenna with which the converter is to be used connected at the time, as changes in the antenna system may make it necessary to readjust the control slightly. Adjusting C_1 causes slight shifts in oscillator frequency, so C_4 should be swung back and forth across the signal as C_1 is peaked. This two-handed adjustment, familiar to all radio servicemen, may require a little practice at first.

That's about all there is to it, and you are ready to listen in earnest. If your locality is one where there is extensive 2-meter activity, you will probably hear something doing on the 2-meter band almost any evening, even with the simplest sort of antenna. In rural districts, or in locations surrounded by high hills, you may find that no signals are audible under ordinary conditions. A high-gain beam antenna and considerable patience may be required in such instances, but experience has shown that 2-meter operation is possible in many locations that appear hopeless at first. The members of your local radio club will probably know who is active on 144 Mc. locally, and the v.h.f. section of *QST* carries extensive reports of 2-meter doings in many parts of the country. Generally speaking there is more 2-meter activity and better DX during the spring, summer, and fall than there is in the coldest months, but considerable operation goes on in many areas on a year-'round basis. In an average location it should be possible to hear stations up to about 50 miles, regardless of weather conditions, and signals out to several hundred miles may be heard when conditions are right.

This converter has been designed to give good 2-meter reception with a minimum of complication. It is nearly equal in performance to the best that it is possible to build, and it may be made to hold its own in top-flight company by the addition of a low-noise r.f. amplifier. The 2-meter beginner who becomes a dyed-in-the-wool addict may want to take this step eventually, but meanwhile he will have a smooth-working receiver that will enable him to hear anyone he can work with low power, and probably a good deal more.

The Transmitter R.F. Section

In designing a crystal-controlled transmitter for 144 Mc. we can use a low-frequency crystal (6 or 8 Mc.) and several frequency-multiplier stages to get to 144 Mc., or we can start with a higher crystal frequency and employ fewer multiplying stages. The former approach has the merit of permitting the use of inexpensive crystals, but the high-frequency crystal technique used here makes for simpler design. It is possible to obtain crystals for frequencies higher than 24 Mc., but they are quite expensive and somewhat critical to use. The 24-Mc. crystal is a good compromise between these two extremes.

The transmitter described here was designed to be duplicated at moderate cost, and with a minimum of trouble, by the inexperienced amateur. It is capable of running about 15 watts input, enough power to work out on 144 Mc.; and

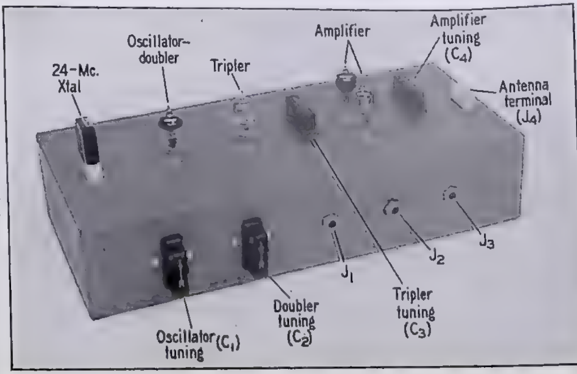


Fig. 45 — Top view of the 2-meter transmitter. 6J6 tubes are used throughout, the two in the output stage being connected in push-pull-parallel.

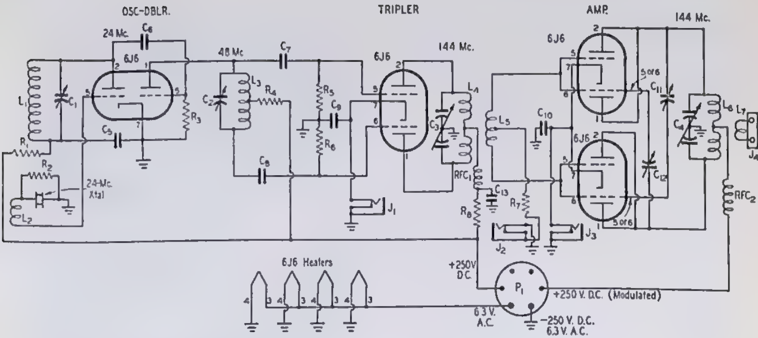


Fig. 46 — Wiring diagram of the 2-meter r.f. unit.

C_1 — 50-μμfd. midget variable (Millen 20050).
C_2 — 15-μμfd. midget variable (Millen 20015).
C_3, C_4 — 6-μμfd. butterfly-type variable (Cardwell ER-6-BFS).
C_5, C_9, C_{10}, C_{13} — 0.005-μfd. disc-type ceramic (Sprague 29C-4).
C_6 — 27-μμfd. ceramic or mica.
C_7, C_8 — 47-μμfd. ceramic or mica.
C_{11}, C_{12} — 3-30 μμfd. mica trimmer (Millen 40001-2).
R_1 — 3300 ohms, 1 watt.
R_2, R_3 — 6800 ohms, ½ watt.
R_4 — 2200 ohms, 1 watt.
R_5, R_6 — 33,000 ohms, ½ watt.
R_7 — 2700 ohms, ½ watt.
R_8 — 1000 ohms, 1 watt.
L_1 — 18 turns B & W Miniductor No. 3003.
L_2 — 3 turns of above. L_1 and L_2 made from a single coil — see text and photograph.
L_3 — 15 turns B & W Miniductor No. 3003, center-tapped.
L_4 — 3 turns each side of center tap, No. 14 enamel, ½-inch inside diameter, turns spaced half wire diameter. Leave ⅜-inch space at center for L_5.
L_5 — 3 turns No. 18 enamel, ½-inch diameter, spaced wire diameter, center-tapped.
L_6 — One turn each side of center, ⅞-inch diameter, No. 14 enamel. Leave ⅝-inch space at center for L_7.
L_7 — 2 turns No. 14 enamel, ⅞-inch diameter, spaced wire diameter.
J_1, J_2, J_3 — Closed-circuit jack. (J_2 insulated from chassis.)
J_4 — Antenna terminal — crystal socket (Millen 33102).
P_1 — 6-prong retainer-ring plug (Amphenol 86-CP-6).
RFC_1, RFC_2 — No. 24 enameled wire close-wound on 1-watt resistor, or Ohmite Z-144 r.f. choke.

it may be used, without modification, as a driver for a higher-powered amplifier at a later date. A single low-cost tube type, the 6J6, is used throughout, and the components are all standard parts that should be obtainable readily in almost any location. The circuit is straightforward and adjustments are not particularly difficult.

Electrical and Mechanical Details

As is often the case with such equipment, the circuit diagram, Fig. 46, looks more complicated than does the equipment itself, but if we take it stage by stage we should not find it hard to follow. The first 6J6 is used as a combination of crystal oscillator and frequency doubler. The first triode section is a regenerative crystal oscillator of noncritical design, the regeneration being added to insure quick crystal starting and adequate power output from the oscillator section. The crystal is a 24-Mc. harmonic-type unit. Output is capacity coupled into the second section, which acts as a doubler to 48 Mc.

The second plate circuit is double-ended, permitting the use of capacity coupling to the grids of a second 6J6 operating as a push-pull tripler to 144 Mc. The output of the tripler is inductively coupled to the grids of a pair of 6J6s connected in push-pull parallel and operating as a neutralized amplifier on 144 Mc. A single 6J6 could be used, but the arrangement shown gives somewhat more output and results in longer tube life than would be the case if a single tube were used and run at maximum ratings. Closed-circuit jacks are included in the cathode circuits of the tripler and final stages and in the grid circuit of the final, to permit metering these stages during the adjustment process. Note that J_2 (final grid current) is *insulated* from the chassis by bakelite washers. This is done to avoid the necessity for reversing meter connections.

Looking at the front-view photograph we see the crystal at the left, followed by the oscillator-doubler, tripler, and final tubes, in that order. The two knobs on the front wall of the chassis are the controls for the oscillator and doubler plate tuning condensers, C_1 and C_2. The knobs on the top of the chassis are on the shafts of the tripler plate condenser, C_3, and the final tuning condenser, C_4. The jacks are spaced along the front wall, and the antenna terminal (a standard crystal socket) is at the far right. Identification of the components in the bottom view follows in the same order, and the arrangement of the coils and other smaller parts is fairly obvious.

Detailed layout drawings are given so that the constructor can make an exact duplicate if he wishes to do so, provided he has parts that are the same as those used in the original. Much of the construction is not critical, however, and

parts that are not mechanical duplicates of the original can be used with good results. Lead lengths are important in the 144-Mc. circuits, however, and the general arrangement of the parts in the tripler and final circuits should be followed closely. The chassis used is larger than is really necessary, but it gives plenty of room to work and results in a neat-looking and accessible layout.

Coil leads and other r.f.-carrying wires should be as short and direct as possible. Other wiring (power leads) may be arranged to suit one's fancy. Ready-wound coils made from B & W Miniductor are used for L_1, L_2 and L_3. The others are wound by hand, of enameled wire. L_1 and L_2 are made from a single piece of Miniductor having 23 turns, with about two inches left at each end for leads. The wire is then cut at the fourth turn in from the end, and one turn is unwound in each direction from the cut. This leaves 18 turns for L_1 and 3 turns for L_2, and takes care of the proper spacing between the two windings. This spacing is fairly critical, as it controls the amount of regeneration, but the correct adjustment is assured if the method of making L_1 and L_2 outlined above is followed.

Spacing between the tripler plate coil, L_4, and the amplifier grid coil, L_5, is also important, and L_5 should be mounted so that it may be moved into or out of the space at the center of L_4, as explained in the adjustment procedure. The same is true of L_6 and L_7.

Variable condensers C_1 and C_2 are mounted on half-inch spacers, to bring their terminals out toward the middle of the chassis and reduce lead length. The rotors are ungrounded, so care should be taken in mounting the condensers to see that there is adequate clearance around the shafts. Also, it should be noted in this connection that knobs made of insulating material should be used, as there is B-plus on the rotors. The butterfly-type variables used in the tripler and final plate circuits have their rotors grounded to the chassis.

Adjustment and Testing

The power supply to be used for testing the transmitter unit should be capable of delivering 150 to 250 volts d.c. at 100 ma. or more, and 6.3 volts a.c. at about 2 amperes. The power supply described later meets these requirements, but for test purposes almost anything that delivers 250 volts or less may be used. Initial checks may be made with 150 volts without worrying about harming the tubes if adjustments are not made correctly, so it may be desirable to connect a 2000-ohm 10-watt resistor in series with the plate supply, if 250 volts is used. This may be shorted out when the adjustments are completed or when a check under full voltage is desired.

Throughout the test procedure the 6J6 plates should be watched closely for signs of overheating. If there is any tendency to show red on the plates the equipment should be turned off at once, as the 6J6s will not stand excessive plate dissipation for long. Reduce the plate voltage, if necessary, before continuing. This may be done by using a series resistor larger than 2000 ohms

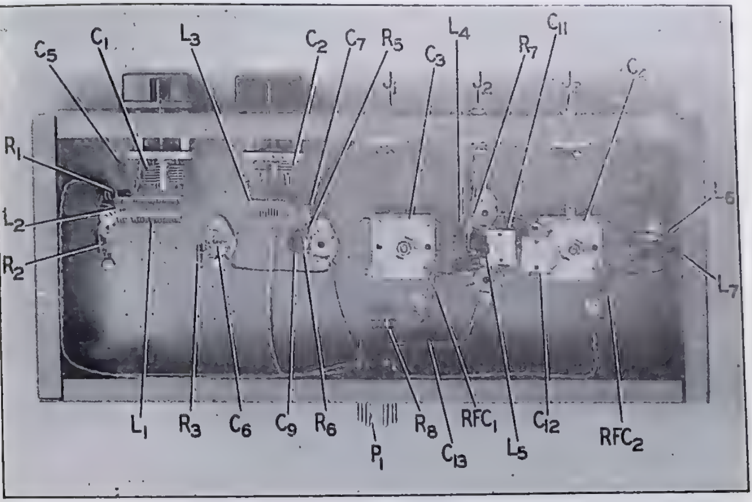


Fig. 47 — Under the chassis of the simple 2-meter transmitter. Components are spaced out for easy assembly and adjustment. Two parts do not show in the photograph. They are C_8 and R_4, out of sight under the doubler plate coil, L_3.

in the power lead. Do *not* apply heater and plate voltages simultaneously; it will ruin the 6J6s in short order. Be sure that the tubes are fully warmed up before applying plate voltage.

Operation of the oscillator should be checked first, and this may be done by applying plate voltage to the first 6J6 section only, at R_1, disconnecting the other B-plus leads. Connect a meter (0–50 or 0–100 ma.) in series with R_1, and rotate C_1 with plate voltage applied. If the oscillator works correctly there will be a dip in plate current as the oscillator starts, with maximum output occurring near the point where the current is lowest. If a calibrated receiver capable of tuning to 24, 48 or 144 Mc. is available, listen to the quality of the oscillator note with the receiver b.f.o. on. It should be a clear, musical note, and the frequency should change only slightly as C_1 is adjusted. If there is a continuous change in frequency, or if the note is rough, the oscillation is probably not being controlled by the crystal. There should be no trouble on this score if the details given for layout and coil dimensions are followed closely. Monitoring may be done with the converter described earlier.

The crystal should be for a frequency between 24 and 24.66 Mc., for operation between 144 and 148 Mc., or 24.16 to 24.49 Mc., for use between 145 and 147 Mc., the limits for novice-class licensees. The one used in the original model is a Valpey CM-5. Another is the Bliley AX-3. These crystals, and recent products of other manufacturers, are quite stable. Some harmonic-type crystals made prior to 1948 may, however, be rather unstable, particularly if the crystal current is high. Otherwise they should work about the same as the newer types in this circuit.

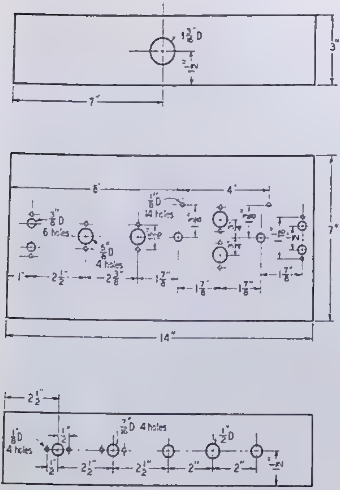


Fig. 48 — Layout drawing of the chassis for the 2-meter transmitter. The large view is looking down at the top of the chassis, with the front wall below and the rear wall above

Some sort of r.f. output indicator will be needed from here on. The simplest is made by soldering a one- or two-turn loop of insulated wire to the terminals of a 2-volt 60-ma. pilot lamp. When this loop is held close to a circuit carrying r.f. the lamp will glow. With 150 volts applied to the stages in this transmitter it should be possible to get some visible indication when the circuits are properly tuned. With higher coltages care should be used in coupling the loop to circuits, as the 60-ma. bulb can be burned out very quickly if it is lighted to more than normal brilliance.

Maximum output will also be nearly coincidental with minimum plate current, but maximum grid current in the stage following the one under test is the best indication. The pilot lamp method may detune the stage somewhat so it is useful principally as a check to see if the stage is working, rather than as an exact indicator of resonance. If a low-range milliammeter (0–10 ma. or so) is available, it may be connected between R_3 and ground, to measure the grid current in the second 6J6 triode section to check the tuning of C_1.

When the oscillator is working properly, apply plate voltage to the doubler, through R_4, and adjust C_2 for maximum output as indicated in the 6J6 tripler stage. This can be measured in J_1, if *no plate voltage* is applied to the stage through RFC_1. Next apply plate voltage to the tripler, through the r.f. choke, and adjust C_3 for maximum output, as indicated by the pilot lamp coupled to L_4. The bulb should glow brightly if 200 volts or more is used on the plates of the tripler stage.

Now plug a milliammeter (0 to 10, or more) into J_2 and check the grid current to the final stage. Adjust the position of L_5 with respect to L_4, retuning C_3 carefully each time the coupling between these coils is changed. The position of L_5 will be found to be quite critical, and it should be set at the point that gives maximum grid current in the final stage, though the exact position need not be found at this stage of the game.

Before plate voltage is applied to the final stage, it must be neutralized. Because it is a triode amplifier there is sufficient feed-back through the grid-plate capacitance of the tubes so that the stage will oscillate unless this grid-plate feed-back is neutralized. So, we feed some voltage of opposite phase back from plate to grid, through the neutralizing condensers, C_{11} and C_{12}. These are the small mica or ceramic trimmers that can be seen in the bottom-view photograph, between the tube sockets and the final tuning condenser.

If mica padders are used, as in the original, they should be screwed down tight and then opened slowly, an equal amount on each side, until turning C_4 produces no change in grid cur-

rent as the circuit is tuned through resonance. This check is made *without* plate voltage on the final. If the stage is not correctly neutralized there will be a sharp downward dip in the grid current as resonance is reached. There may be just a perceptible rise in grid current at resonance, but there should be no downward dip whatever.

When this condition is obtained plate voltage may be applied and C_4 tuned for maximum output, as indicated by a lamp connected across the antenna terminals. Two short pieces of wire can be soldered to the terminals of a 10- or 15-watt lamp, and this used as a dummy load by plugging into J_4. With full voltage (250 volts) a 10-watt lamp should show nearly full brilliance, and a 15-watt bulb will glow a bright yellow.

Thus far we have purposely said nothing about the current values that should be obtained in the various stages, as it has been assumed that the tests outlined would be conducted with voltages somewhat below normal, in the interest of safety, in case some portion of the rig might not be working correctly. Now we are ready for a final adjustment, for normal operating conditions. A maximum of 250 volts should be used for all stages and the adjustments checked to see that they are at optimum all the way along the line. If everything is working correctly the readings should be something like this: oscillator plate current 12 ma., measured in series with R_1; doubler plate current 16 ma., measured in series with R_4; tripler cathode current 30 ma., measured in J_1; final grid current 12 ma., measured in J_2; final cathode current 55 ma., measured in J_3. Of this final cathode current, only 43 ma. (cathode current minus grid current) is plate current, and that figure multiplied by the plate voltage gives the final-stage input. It should be around 10 watts, with the power supply described, and not more than 15 watts under any condition. This is well within the ratings for the 6J6s, yet is enough power to have a lot of fun on 144 Mc., or to drive a higher-powered amplifier later on.

The Modulator

As most operation on 144 Mc. is by means of voice (A3 emission) or tone-modulated telegraphy (A2), it is necessary to have a modulator as part of our 2-meter station. A suitable modulator design is shown in the first photograph, and the schematic diagram is given in Fig. 50. The modulator is nothing more than a common audio amplifier, with an output transformer of suitable design so that the power input to the final stage of the transmitter may be modulated (varied) in proportion to the variations in level of the operator's voice. The only essential difference between the modulator and an audio system such as used in a receiver or a phonograph amplifier is in the type of output transformer used. In our modulator the output transformer (T_2) is designed to carry the current to the final stage of the transmitter through its secondary winding. The audio voltage developed in the modulator is thus added to or subtracted from the voltage impressed on the final stage — a simple explanation of the modulation process.

Only three tubes are used in the modulator. The first is a 6SN7GT dual triode, the first section of which is connected as a grounded-grid amplifier, with the microphone inserted in its cathode lead. This very simple arrangement does away with the necessity for a microphone trans-

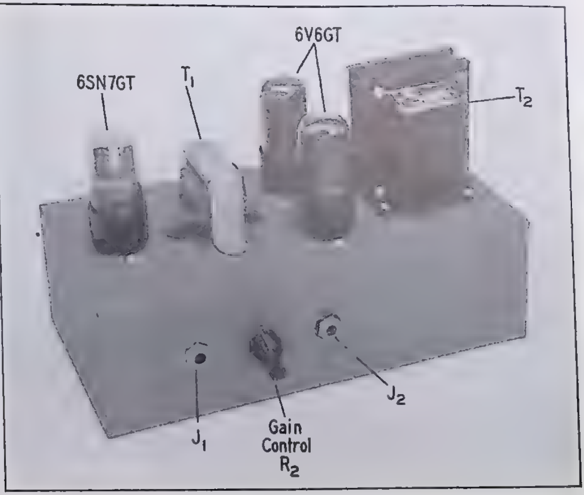


Fig. 49 — Modulator for the 2-meter station.

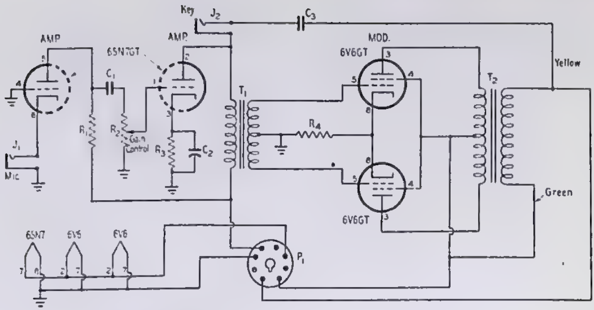


Fig. 50 — Wiring diagram of the modulator for the 2-meter station.

C_1 — 0.01-μfd. disc-type ceramic.
C_2 — 25-μfd. 25-volt electrolytic.
C_3 — 0.003-μfd. tubular.
R_1 — 47,000 ohms, ½ watt.
R_2 — 0.5-megohm potentiometer.
R_3 — 1500 ohms, 1 watt.
R_4 — 250 ohms, 10 watts.
J_1, J_2 — Open-circuit jack.
P_1 — Retainer-ring type plug, 8-pin male (Amphenol 86-CP-8).
T_1 — Small input transformer, single plate to push-pull grids (Stancor A-4713).
T_2 — Modulation transformer, push-pull 6V6s to 5000-ohm load (Stancor A-3845).

former, and also takes care of the current necessary for the operation of a carbon microphone. These are, in fact, the reasons for the use of the stage at all as the following triode amplifier provides more than enough gain for the 6V6GT modulators.

The potential output capability of the modulator is considerably in excess of the requirements of the transmitter. It was considered advisable to design it in this way so that, with minor changes, it could be use dwith a higher-powered transmitter at a later date if desired. The output transformer has a 25-watt rating, so the modullator could be used with a transmitter of 50

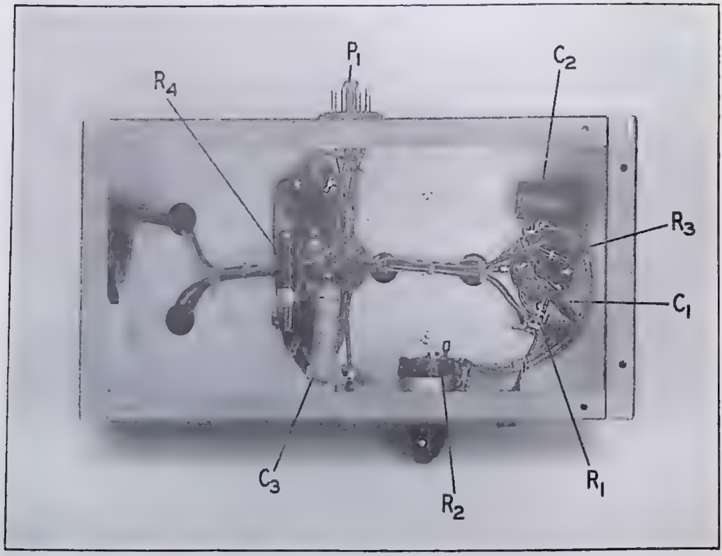


Fig. 51 — Bottom view of the modulator. The 6SN7GT socket is at the right. Extra leads to the modulation-transformer secondary are taped together at the left.

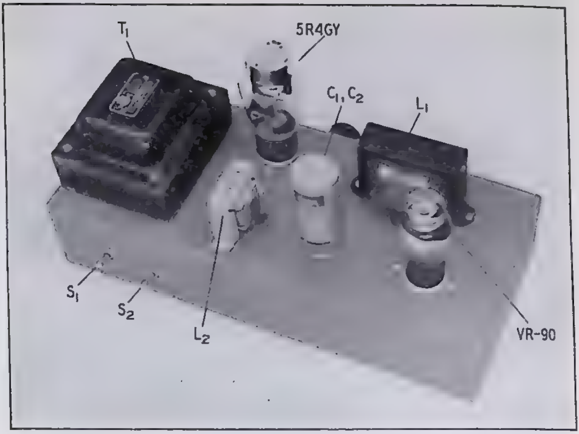


Fig. 52 — Power supply for the 2-meter station. This one unit delivers the necessary a.c. and d.c. power for the transmitter, modulator and converter.

watts or more, by using 6L6s and slightly altering the operating conditions. There is no harm in having an oversized modulator, so long as the operator is careful to keep the gain control (R_2) set for only as much power output as is needed to modulate the power input being used.

It is often desirable to be able to transmit in code when working on 144 Mc. Use of a keyed tone of constant pitch provides a somewhat more readable signal under adverse conditions than does voice modulation, and communication with this type of modulation (usually called m.c.w.) is an excellent way to build up one's proficiency with the code. Fortunately, inclusion of tone modulation is possible with almost no increase in complication or cost, by merely providing a means of feed-back in the modulator. The condenser C_3 is used for this purpose, feeding back energy from the modulator output into the primary of the input transformer. The key is plugged into J_2 (note that this jack is *insulated* from the panel). It may be left there permanently, if so desired, and tone modulation is thus constantly avaialble. The pitch of the tone may be varied by changing the value of the feed-back condenser, C_3.

Construction of the modulator is extremely simple, and almost no special precautions are necessary. The heater leads and the leads to the gain control were wired with shielded wire, to forestall any chance of r.f. feed-back or hum pick-up, but this is probably not absolutely necessary in such a simple circuit. Nothing about the parts arrangement is critical, and almost any convenient layout may be used with good results. Other tubes and different components may also be used. For example, if one wants to build a smaller unit, miniature tubes (12AU7 amplifier, 6AQ5 modulators) may be substituted, and a smaller output transformer may be used. The layout shown has the advantage of being converted easily to higher-power service, however. Operation of the modulator will be covered later, in the discussion of the final set-up for the complete station.

Full modulation and best quality are possible only if the modulator is "matched" to its load. The transformer used in this equipment has secondary taps for impedances of 8000, 6500, 5000, and 3000 ohms. The load impedance that the amplifier presents to the modulator is found by Ohm's Law. Simply divide the final plate voltage by the plate current. In this instance we have the plate voltage, 250, divided by the plate current, 0.05 amp., or a load impedance of approximately 5000 ohms. If a transformer other than the one specified is to be used, be sure that it is capable of working into a load of approximately 5000 ohms.

Power Supply

Power-supply equipment is something that everyone must have to run a station, regardless of the type of operation he engages in. And we all need low-voltage supplies, too, so it pays to build a good one right at the start. There will always be uses for it later on. The power supply for our 2-meter station handles both the transmitter and the receiver, switching of the various circuits being handled by a control unit, shown in the composite photograph of this series. Details of the control unit and cabling system are shown in Fig. 54.

Looking at the schematic diagram of the power supply, Fig 53, it may be seen that a 2-section filter system is used, but the second section supplies only the converter and the speech amplifier. These stages require better filtering than do the modulator tubes and the transmitter r.f. section, but they draw only a small amount of current, permitting a small inexpensive filter choke (L_2)

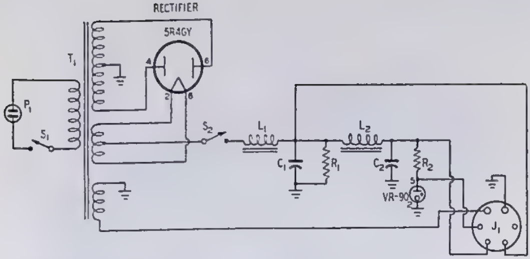


Fig. 53 — Schematic diagram of the power supply.

C_1, C_2 — Dual 8-μfd. 450-volt electrolytic condenser.
R_1 — 50,000 ohms, 10 watts.
R_2 — 2500 ohm, 10 watts.
L_1 — 7-hy. 150-ma. filter choke (Stancor C-1710).
L_2 — Any small filter choke, 50-ma. or more rating.
J_1 — Retainer-ring type plug, 6-pin female (Amphenol 78-S6).
P_1 — Retainer-ring type 115-volt receptacle (Amphenol 61-M).
S_1, S_2 — Single-pole single-throw toggle switch.
T_1 — Power transformer: 700 volts at 200 ma., center-tapped; 5 volts at 3 amp., center-tapped; 6.3 volts at 5 amp.

to be used in the second section. The first filter choke, L_1, must be of larger construction, as the entire current drain of the station runs through it.

More stable operation of the converter is possible if its plate voltage is maintained at a constant value, regardless of load and line-voltage variations. This is accomplished with a gaseous voltage-regulator tube, the output of which is used on the converter tubes only. Either a VR-90 or a VR-105 may be used.

Two toggle switches control the operation of the power supply. One is connected in the primary circuit of the power transformer and the second in the lead to the rectifier filament center tap. It is thus possible, by means of S_2, to have the 6.3 volts a.c. applied to the tubes in the transmitter, receiver and modulator, and still have no high voltage applied to any of these units. The primary switch, S_1, is closed first, allowing the tubes to reach operating temperature, before S_2 is thrown to the "on" position. Be sure that this process is always followed, as application of the plate and heater voltages simultaneously will damage the 6J6 tubes in the transmitter.

The Control Panel

Arranging a satisfactory control system is one of the most difficult jobs in assembling a satisfactory station for some amateurs. Ideally, the complete operation of the station should be controlled from one switch, the functions of which include turning on the transmitter, cutting off the receiver, and switching the antenna from one unit to the other, all in a single motion. In large amateur stations these functions are usually accomplished (in an infinite variety of ways) by means of one or more relays, operating from the main control switch. In our set-up we handle the job with a single inexpensive selector switch capable of connecting four leads to either of two positions.

A glance at the diagram of the control circuits, Fig. 54, will show how this is done. The main control switch S_1, carries two circuits for the an-

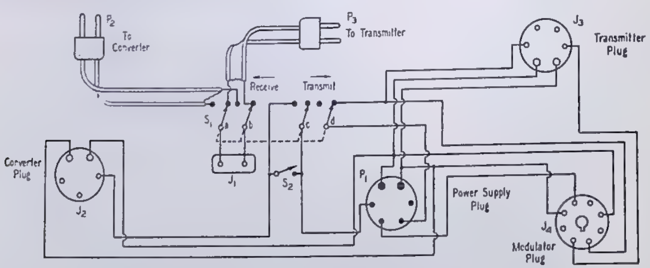


Fig. 54 — Diagram of the cabling system used to supply power to the various units in the 2-meter station.

J_1 — Antenna terminal — standard crystal socket (Millen 33102).
J_2 — Multiwire cable connector, 5-pin female (Amphenol 78-PF5).
J_3 — Multiwire cable connector, 6-pin female (Amphenol 78-PF6).
J_4 — Multiwire cable connector, 8-pin female (Amphenol 78-PF8).
P_1 — Multiwire cable connector, 6-pin male (Amphenol 86-PM6).
P_2, P_3 — 300-ohm line plug (Millen 37412)
$S_{1A, B, C, D}$ — 4-circuit 2-position rotary switch (Mallory 3242J).
S_2 — Single-pole single-throw toggle switch.

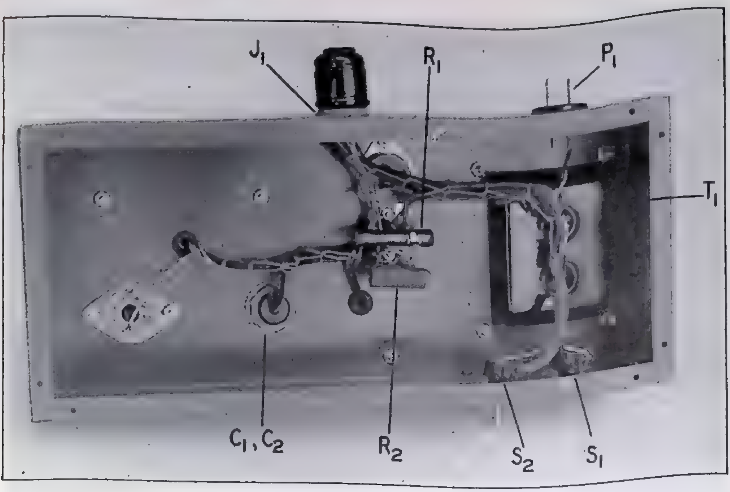


Fig. 55 — Bottom view of the power supply.

tenna, one for the high voltage for the transmitter, and one for the regulated voltage for the converter. When the switch is in the "transmit" position, as in Fig. 54, it will be seen that all the transmitter circuits are supplied with the necessary voltages through S_{1d}, and the antenna is connected through the switch to the transmitter terminals through sections *a* and *b*. If S_2 is left open there will be no plate voltage on the receiver circuits. Then, when we throw the control switch to the "receive" side the transmitter is disabled, the plate voltage is applied to the receiver through S_{1c}, and the antenna is connected over to the receiver input terminal. The switch S_2, seen in the composite photograph, Fig. 39, at the lower right of the control panel, is included so that the receiver can be operated while the transmitter is on, for monitoring purposes if desired.

Just above the main control switch is the antenna terminal, into which the feeder from the antenna system is plugged. This is a standard crystal socket, as convenient plugs for these sockets, for use with 300-ohm line, are now available from several manufacturers. The ones used here are Millen type 37412.

There is an elementary safety point in laying out power cabling in radio work that is often overlooked. The "hot" terminals in the power circuits should be recessed so that no contact can be made with them by the operator, if the power supply is accidentally turned on when no connection is made to it externally. This calls for the use of female-type connectors on the power side of such junctions, with the male type being used on the detachable part. At the opposite end of the cable the reverse is true, of course.

Making up the cables will be simpler if several colors of wire are available, as it is difficult to keep them identified otherwise. When the cable wires have been made up and soldered in place the system can be made neat by lacing up the cables. Waxed lacing twine made especially for this purpose is available, but soft cotton package twine may be used. Lacing up the power wiring under the chassis of the two units is a refinement that adds to their neatness.

Final Tests and Operation

We are now about ready to go on the air with our complete station. A convenient arrangement of the component parts is shown in the composite photograph. The power supply and transmitter r.f. unit are mounted in a simple wooden rack to conserve space and make for convenience in testing and operation. The rack is made of 1 by 2-inch wood, known as furring strip in the lumber yards. Its construction should be obvious from a glance at the photograph.

The control panel is screwed to the rack at the lower right side, so that the change-over switch and the converter dial, the two most-used controls, are near together. Obviously, this layout was set up for a right-handed operator, but there is nothing critical about the arrangement, and it may be altered to siut one's own ideas and personal preference.

Before putting the unit on the air we will check out the final set-up with a dummy load. With the cables connected properly and the 300-ohm lines plugged into their terminals on the transmitter and converter we are ready to go.

The 15-watt bulb that was connected to the transmitter for the initial tests may now be plugged into the antenna terminal, J_1, on the control panel. Throw the primary switch in the power supply on, and allow the tubes in all units to heat up. Then turn on the plate power switch, S_2, with the main control switch in the "transmit" position. If the rig is tuned up properly, the lamp load will light up, though a somewhat different setting of the transmitter coupling coil, L_7 in Fig. 46, may be required. Final adjustment of the coupling to the antenna, and also the coupling between the tripler plate and final grid coils, may be done easily by tipping the transmitter unit up and resting it on the rack shelf with the bottom toward the operator. Check the neutralization adjustments carefully at this time.

When everything is in order, plug in the microphone and check for modulation, turning the gain control up until there is an appreciable brightening of the load lamp at ordinary voice level. Hold the microphone close to the lips, and turn the gain up only as far as is necessary to develop a satisfactory modulation level. Higher gain will result in overmodulation on voice peaks, and increase the pick-up of noises remote from the microphone.

If modulation produces a dimming of the lamp brilliance you have "downward modulation" which may result from too tight antenna coupling or insufficient grid drive. Check your 6J6s and make sure that the best ones are in the tripler and final-stage sockets, the best ones being those that give the highest grid current. The loading on the final, by either the lamp or the antenna, should be set at a point where there is still an appreciable dip in final cathode current when the final plate condenser is tuned through resonance. Increasing the coupling beyond this point will result in no increase in output, and going too far will actually reduce the output, and cause downward modulation. The position of the coupling coil may be different when the antenna is used, so a check should be made for upward modulation when the antenna is connected. A neon bulb held near the final plate coil should show an increase in brilliance when modulation is applied.

Next plug a key into J_2 in the modulator, and check the tone modulation. The quality of the note will usually be best with the gain control at a low setting, probably somewhat lower than is needed for voice modulation. The tone pitch may be raised or lowered by decreasing or increasing the value of the feed-back condenser, C_3.

Be sure that the oscillator and tripler controls and the coupling between the tripler and final stages are set carefully so as to give the greatest amount of grid current in the final tubes. Only when this condition is satisfied, and the coupling to the antenna is correctly adjusted, will the transmitted signal be of the best quality and strength.

Antenna Systems

The station is designed to operate with an antenna system fed with 300-ohm line. This can be the ribbon commonly used for television antenna installations, or the heavy-duty variety designed for high-powered transmitters. There are innumerable types of antenna systems that can be adapted to 2-meter work, and typical designs may be found in *The Radio Amateur's Handbook*, and the *A.R.R.L. Antenna Book*. New designs of special mechanical or electrical interest are published from time to time in *QST*.

Probably the simplest antenna, and one that is quite suitable for local work is the folded dipole, shown in Fig. 56. This may be made of any metallic rod or tubing stock that can be bent into the desired shape, or it may even be made of the 300-ohm line itself. The latter arrangement is often used for indoor antennas, with the dipole fastened on a wall of the operating room. Such an antenna may be used either vertically or horizontally. The position should be determined by the polarization in use in one's own neighborhood. Except under very favorable conditions one cannot expect to work more than 30 or 40 miles with such simple antenna systems. This may be enough to provide many contacts in areas of dense population, but the enterprising 2-meter enthusiast will want something better soon.

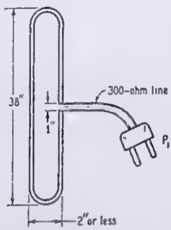


Fig. 56 — A simple antenna for 2-meter work is the folded dipole. This may be made of any metal tubing, rod, or wire that may be bent into the desired shape. It is fed with 300-ohm Twin-Lead, terminated with a Millen 37412 plug, to fit the antenna terminal on the control unit. The antenna may be used either horizontal or vertical, depending on the polarization used in one's own locality.

Experimental work with high-gain antenna arrays is, in fact, one of the most intriguing fields of amateur endeavor. Because of the relatively-small size of arrays for 144 Mc. the 2-meter worker can almost always find room for something better than the simplest dipole, and he will find that the results obtained will be almost directly proportional to the effort he spends in putting up the best antenna system that is within his means.

Arranging the Station

It is helpful to arrange the station neatly and to keep paper, pencils, the log book, etc., where they are always handy. Furthermore, it is as easy to make a shipshape job of the station as to have it look "haywire." You do not want to have to apologize for the appearance of your equipment.

The operating table should be as roomy as space permits. Place the receiver at a distance

back from the front edge that will permit you to operate it with comfort. The transmitter, which requires readjustment only when you change frequency, may be placed farther back on the table if desired. It is advisable to space the receiving and transmitting units at least a foot apart. Place the key in the position where it can be handled most comfortably.

If cables are provided for the power supplies, power units may be placed on a shelf or on the floor under the table. Make sure, however, that they are not within easy reach of your feet.

Since the antenna feed-line wires probably will be brought in at the window as a convenience, place the table as close to the window as conditions permit. While the 300-ohm line for the v.h.f. antenna may simply be brought directly in under or over a window sash, the simplest way of bringing an open feed line in to the transmitter is through medium-size feed-through insulators set in a strip of wood. This strip should be a couple of inches wide and only slightly shorter than the width of the window sash, so that it may be slipped in place in the window frame, either over the top sash or under the bottom sash. When the window is closed against the strip, there will be only a slight overlap of the sashes at the center.

When you have the board in place, cut enough wire off the feed line to reach from the transmitter output terminals to the inside terminals of the feed-through insulators. Then attach the feed line itself to the outside terminals of the insulators. (The feed-line lengths shown in the table include the wire inside the station.)

When operating at the lower frequencies, it is common practice to use a separate antenna for receiving, not only because it is more convenient but also because it will permit you to change back and forth between transmitting and receiving with a minimum loss of time. You can start transmitting immediately after the station you are working signs off, without the need to throw switches. Good results can be expected with a single wire anywhere between 25 and 150 feet long, indoors or outside. The longer outside antenna will give somewhat better results, of course, but you should hear plenty of strong signals on a wire running around the picture moulding, or even laid across the floor if a better antenna isn't possible. If the separate antenna is put up outside, it should be placed as far away from the transmitting antenna as practicable and run as near at right angles to the transmitting antenna as possible.

The 80- and 40-meter transmitting antenna will, of course, make an excellent receiving antenna. To use the antenna for both purposes, it will be necessary to provide a switch. An ordinary porcelain-base double-pole double-throw knife switch is suitable. The feed-line wires are brought to the two central terminals of the switch instead of to the transmitter. One pair of end terminals should be wired to the receiver input terminals, while the other end terminals connect to the transmitter output terminals.

If a grounded Marconi-type antenna system is used for 80- and 40-meter work, the ground wire should run as directly as possible to a water pipe. Special clamps for connecting to water pipes are available. With a grounded antenna, only the single wire need be switched for receiving.

Licenses

As we have said before, you must have a government license before you can go on the air with your transmitter. The amateur license is really two licenses in one: one for the station, the other a personal amateur operator license. Both are required by law, and are issued by the Federal Communications Commission. The license costs nothing, but, in the case of the operator portion, requires some study of elementary theory and the U.S. radio laws and regulations as they apply to amateur stations. This knowledge is not difficult to acquire, however, and if you start to study at about the same time you start construction of the station, you should be adequately prepared by the time the station is finished.

At this point we may say that only citizens of the United States are eligible for either station or operator licenses. In addition, a station license will not be issued, even to a citizen, if the transmitter is to be located on property which is controlled by an alien.

The station portion of the license is your station's official "registration"; it licenses your transmitter for operation in the amateur bands and designates the call to be used. It is issued after filling out a form provided for the purpose—no examination is given in connection with it. However, station authorizations are issued only to persons who also qualify for operator licenses. Actually, both operator and station authorizations are combined in a single card license.

The operator portion of the license is your personal authorization to operate an amateur station — not only your own station but any amateur station within the privileges of both operator and station license. Applicants living within 125 miles airline of one of the examining centers designated by the FCC * have to appear in person at those cities for their examination,

* Anchorage, Alaska; Atlanta, Ga.; Baltimore, Md.; Beaumont, Tex.; Birmingham, Ala.; Boston, Mass.; Buffalo, N. Y.; Charleston, W. Va.; Chicago, Ill.; Cincinnati, Cleveland and Columbus, Ohio; Corpus Christi and Dallas, Tex.; Davenport, Ia.; Denver, Colo.; Des Moines, Ia.; Detroit Mich.; Ft. Wayne, Ind.; Fresno, Calif.; Grand Rapids Mich.; Honolulu, T. H.; Houston, Tex.; Indianapolis, Ind.; Jackson, Miss.; Juneau, Alaska; Kansas City, Mo.; Knoxville, Tenn.; Little Rock, Ark.; Los Angeles, Calif.; Memphis, Tenn.; Miami, Fla.; Milwaukee, Wis.; Mobile, Ala.; Nashville, Tenn.; New Orleans, La.; New York, N. Y.; Norfolk, Va.; Oklahoma City, Okla.; Omaha, Nebr.; Philadelphia and Pittsburgh, Pa.; Phoenix, Ariz.; Portland, Ore.; St. Louis, Mo.; St. Paul, Minn.; Salt Lake City, Utah; San Antonio, Tex.; San Diego and San Francisco, Calif.; San Juan, P. R.; Savannah, Ga.; Schenectady, N. Y.; Seattle, Wash.; Sioux Falls, S. D.; Syracuse, N. Y.; Tampa, Fla.; Tulsa, Okla.; Washington, D. C.; Williamsport, Pa.; Winston Salem, N. C.

and have to pass the code test as given by the radio inspector. Those living more than 125 miles from one of these points are permitted to take the examination by mail and have the code test given them, under oath, by an already licensed operator. There are at present six classes of amateur licenses — Amateur Extra, Advanced, General, Conditional, Novice and Technician.

Advanced and Extra Class are licenses which are related to special experience requirements and separate examinations, so you as a newcomer will not now be interested.

General Class is the "standard" amateur license. It conveys all amateur privileges. Conditional Class authorizes the same privileges, except that it is issued to persons who take the examination by mail whereas General Class is issued to those who take the examination before an FCC representative. For either license, you must pass an examination including a code test at 13 words per minute and a written test on radio fundamentals (basic theory and practice) and regulations governing amateur operation. There are about 50 questions; approximately two-thirds are on technical subjects, while the remainder concern themselves with the United States radio laws and the amateur regulations. These licenses run for five-year terms and may be renewed upon showing of amateur activity.

The Technician Class license requires the standard written examination but a code test of only 5 w.p.m. It authorizes operation only on amateur bands above 220 Mc.

The Novice Class is the simplest steppingstone to amateur radio and will therefore be of primary interest to you. It requires the slower code test of 5 w.p.m., and only a very simple written quiz. At the same time it conveys restricted privileges: use of c.w. (code) only in 3700–3750 kc., 7175–7200 kc. (and, effective March 28, 1953, in 21,100–21,250 kc.), and code or voice on 145 to 147 Mc. Maximum power permitted is 75 watts, and the frequency must be crystal-controlled. Provided you select a crystal in the range 3700–3750 kc., or 7175–7200 kc., therefore, either of the two transmitters described earlier in this booklet will be ideal for operation as a Novice. And the 145-Mc. gear described is similarly ideal for a Novice who wishes to use that band as a starter. The Novice Class is therefore an excellent means of entry into amateur radio, since it has a very minimum of requirements and yet adequate privileges for you to sample the various kinds of activities that take place in the amateur bands. The license examination may be taken by personal appearance at one of the FCC offices or, if you live more than 125 miles from any of the points listed earlier, you may take the exam by mail.

However, the Novice Class license will be good for only one year *and may not be renewed.* It is designed primarily to give newcomers to amateur radio a chance to learn by practising, and the idea is that inside of one year of activity on the air you should easily bring your code speed up to the point where you can pass the regular examination and become a full-fledged amateur with rights to use the other amateur bands. So, if you aim for the Novice Class as a start, remember it's only a stepping stone, and keep in mind that you'll want to work toward the General Class (or Conditional Class, if you live more than 125 miles from an examining point) as soon as you get on the air as a Novice.

The subject of preparing for the written examination is beyond the scope of this booklet. Although the examination deals with elementary radio, it is necessary to engage in some study for it. If you will carry out this study in conjunction with the constructing of your apparatus, you will find that your reading helps you to understand the operation of your sets and your construction of the equipment helps you to absorb the new knowledge. You are going to obtain an immense amount of enjoyment from amateur radio; it is well worth learning about. In the first place, if you do not possess a fair knowledge of elementary electricity, such as is taught in a high school physics course, we suggest that you obtain from your local library a good elementary electrical textbook. That is the groundwork for all radio theory. Then you should read a book that deals with radio itself in equally simple fashion, explaining elementary radio theory and the functioning of simple practical apparatus. Any satisfactory available text may be used, of course, but we would recommend that you obtain a copy of *The Radio Amateur's Handbook*, an American Radio Relay League publication which is a complete manual of amateur electrical and radio theory, construction and operation. While you will eventually find a personal copy of this book indispensable, you will probably be able to borrow a copy or find it at your local public library. In U.S.A., it may be obtained from the League for $3.00, postpaid.

We also earnestly suggest that before going up for your test you obtain a copy of *The Radio Amateur's License Manual.* This booklet explains in detail the procedure in applying for licenses, lists many questions similar to those that will be asked in the examination and gives their correct answers, and includes the full text of the amateur regulations and pertinent portions of the radio law. The *Handbook* may be borrowed, but you should purchase a copy of the *License Manual,* for it is really indispensable to the new applicant. We very much wish that it were possible to publish the contents of that booklet in this one, but it is of almost equal size and it is not economically practicable to do so. The current edition of the *License Manual* may be obtained from the ARRL at West Hartford 7, Conn., 50¢.

Practise sending, too, on your practice outfit, for in your code test you have to demonstrate ability both to send and receive. You will undoubtedly find it a lot easier to send than to receive — everybody does. But don't try to hurry your sending. Grasp the key lightly but definitely with the thumb and first two or three fingers of the hand, and adjust the key so that there

is an up-and-down motion of about one-sixteenth of an inch at the knob. Use a wrist motion. Learn to make the characters evenly and distinctly. *Don't* try to send fast. One of the surest indications of a beginner on the air is the fellow who tries to send rapidly and only makes an unintelligible mess of everything. It is a good idea to keep your sending speed on a level with your receiving speed.

There is nothing difficult about the examination for a person of average intelligence and application. Thousands of Americans have qualified. Your license, when you get it, will have a term of five years and, provided you show even a small amount of activity as an operator, may be renewed indefinitely without further examination of any kind. That is, except for the Novice Class, which will be good only for a year.

Getting On the Air

And now, after you have built your receiver and transmitter and put them in operating condition, have obtained your licenses, and have learned something of the customs and practices of operating, you are ready to take your final step — the step for which you have worked through all these weeks — your first actual operation on the air as an amateur.

You sit down some evening before your receiver and light up the tubes. Tuning in on the 3500-kc. band, let us say, you hear some station (not too far away!) sending a "CQ" and finally signing his own call. You turn on your transmitter, and call that station — just a bit shakily, no doubt. After making a reasonably long call, you sign off and listen for him again. Perhaps he does not come back. Too bad! — but don't be discouraged. While it has happened that amateurs have worked the first station they ever called, this experience is not the rule. Try again. Perhaps you will still fail to "connect," and you may call all that evening without working anybody.

But you keep on trying the next night, and soon there comes a time when you enjoy that never-to-be-forgotten thrill of hearing the other fellow call your station. And then you talk with him, learn where he is, and hear him tell you how good your signal is at his "shack" and perhaps make a schedule to call him again the next night for another talk. So you start to learn the thrill and pleasure that come from talking to another fellow-being hundreds (even thousands) of miles away, from the privacy of your own home, and with apparatus that you have constructed with your own hands. It is a thrill that never wears off.

It is probable that one of the first things you will be asked, when you begin working other amateurs, is to "Pse QSL OM." What the other fellow is referring to is a custom that has grown to be a part of amateur radio, known as the exchanging of QSL (acknowledgment) cards. Most amateurs have postcards printed up with their call prominently displayed, and other data on their station. leaving space of course to put the call of the amateur to whom they are going to send the card. When you work some distant amateur, he may ask you (or you may ask him) to exchange cards, as noted above. You then make out one of your cards, address it to him, and mail it, usually receiving one of his in return. Many amateurs have the walls of their operating room literally plastered with QSL cards from all over the world.

Oh yes — don't forget to keep a log of your station operation. For one thing, the United States amateur regulations require you to do this, but aside from that every worthwhile amateur keeps a neat log as a matter of pride. Your log should record all calls made by the transmitter, calls of station worked, time, frequency band and power of your transmitter, and the name of the operator.

You are now a full-fledged amateur, and ready to take your place in the amateur ranks. Do not try to hurry matters in building your station or operating it. Be a gentleman on the air and don't be afraid to admit that you are a beginner. If someone sends too fast for you, tell him so — don't give some lame excuse such as "QRM" or "QRN" for having missed some of his remarks. A genial request to send slower will practically always get the desired result, and those you are working will think more of you for it.

The American Radio Relay League, at West Hartford 7, Conn., which publishes this pamphlet, is a society of and for amateurs, and it will be more than glad to help you out with your problems. It may be that, later, you will wish to become a member of the League. Most active amateurs are members. Station ownership is not necessary to membership — you have only to be interested in amateur radio. Dues are $4.00 a year, $4.25 in Canada (foreign $5.00) and include a year's subscription to the monthly magazine *QST*, often referred to as the "amateur's bible." Every amateur reads *QST*; each month's issue is filled with information on the latest types of receivers and transmitters, and news from all over the country. If you cannot obtain it from your newsstand, a sample copy may be obtained for 40 cents from the ARRL.

THE "Q" CODE

As explained in the text of this booklet, this is a very useful internationally-agreed code designed to meet major needs in international radio communication. There are several times as many "Q" signals as those we list here, but those omitted bear primarily upon commercial radio and have little application in amateur contacts. The abbreviations themselves have the meanings shown in the "Answer" column. When an abbreviation is followed by the signal for an interrogation mark (• • ▬ ▬ • •) it assumes the meaning shown in the "Question" column.

Abbreviation	*Question*	*Answer*
QRG	Will you tell me my exact frequency (*or* that of . . . .)?	Your exact frequency (*or* that of . . . . . .) is . . . . . . kc/s (*or* Mc/s).
QRI	How is the tone of my transmission?	The tone of your transmission is . . . . (1. Good 2. Variable 3. Bad)
QRK	What is the readability of my signals (1 to 5)?	The readability of your signals is . . . . . . (1 to 5).
QRL	Are you busy?	I am busy. Or (I am busy with . . . . . .). Please do not interfere.
QRM	Are you being interfered with?	I am being interfered with.
QRN	Are you troubled by atmospherics?	I am troubled by atmospherics.
QRO	Shall I increase power?	Increase power.
QRP	Shall I decrease power?	Decrease power.
QRQ	Shall I send faster?	Send faster (. . . . . . words per minute).
QRS	Shall I send more slowly?	Send more slowly (. . . . . words per minute).
QRT	Shall I stop sending?	Stop sending.
QRU	Have you anything for me?	I have nothing for you.
QRV	Are you ready?	I am ready.
QRX	When will you call me again?	I will call you again at . . . . . . hours (on . . . . . . kc/s (*or* Mc/s).
QRZ	Who is calling me?	You are being called by . . . . . . (on . . . . . . kc/s (*or* Mc/s).
QSA	What is the strength of my signals (1 to 5)?	The strength of your signals is . . . . . . (1 to 5).
QSB	Are my signals fading?	Your signals are fading.
QSD	Is my keying defective?	Your keying is defective.
QSL	Can you acknowledge receipt?	I am acknowledging receipt.
QSO	Can you communicate with . . . . direct or by relay?	I can communicate with . . . . direct (*or* by relay through . . . .).
QSP	Will you relay to . . . . free of charge?	I will relay to . . . . free of charge.
QSV	Shall I send a series of V's on this frequency? (*or* . . . . kc/s (*or* Mc/s).	Send a series of V's on this frequency (*or* . . . . kc/s *or* Mc/s).
QSY	Shall I change to transmission on another frequency?	Change to transmission on another frequency (*or* . . . . . . kc/s (*or* Mc/s).
QSZ	Shall I send each word or group more than once?	Send each word or group twice (*or* . . . . . . times).
QTA	Shall I cancel telegram No. . . . . . . as if it had not been sent?	Cancel telegram No. . . . . . . as if it had not been sent.
QTC	How many telegrams have you to send?	I have . . . . . . telegrams for you or for . . . . . .
QTH	What is your location?	My location is . . . .

DANGER! HIGH VOLTAGE!

In some of the equipment described in this booklet the voltage between certain points may run as high as 800 or 900 volts. Since individuals sometimes are killed by coming in contact with ordinary 115-volt home lighting circuits, the beginner must forever be aware of the potential danger attached to *careless* handling of amateur radio equipment — particularly transmitters.

Make it your *first* rule to form the habit never to touch anything behind the panel of a receiver or transmitter without first turning off *all* power. Thousands of amateurs, young and old, work daily with equipment carrying voltages as high as 8000 or 10,000 with complete safety. But the operator should never forget for a moment that harmless-appearing gear can and has been lethal in isolated instances when the operator became careless. NEVER TOUCH ANYTHING BEHIND THE PANEL UNTIL YOU ARE CERTAIN THAT ALL POWER HAS BEEN TURNED OFF!

"Bible" OF HAM RADIO . . .

Twelve times a year a magazine is delivered to the door of nearly every active amateur in the country, chock full of the latest news of ham doings.

These amateurs are members of the American Radio Relay League, the organization which publishes this booklet. The magazine is the amateur's "bible," *QST*.

In the pages of *QST* you meet the fellows you hear and work on the air. You get operating data, available nowhere else, to help you become a better operator and to get more fun from your activities.

No matter what your principal interest may be — rag-chewing — traffic — DX — experimenting — contests — v.h.f. — you will find extra space in *QST* devoted to your specialty.

You get the newest and latest technical developments. Throughout *QST*'s thirty-five year history it has consistently presented the important developments in the radio art — first. It is written and edited by amateurs for amateurs.

Yes, *QST* is the amateur's own magazine. You will be one of its owners, through your membership in ARRL. You can contribute to it from the accomplishments of your own home experimenting. You will have a warm, friendly, personal sense of pride in *QST* — your own magazine!

ARRL, 38 Lasalle Road, West Hartford 7, Conn.

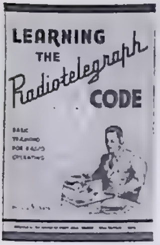
Yes, I want *QST* to keep me up-to-date on ham activities. Enclosed is $............ ($4 in the U.S. and possessions; $4.25 in Canada; $5 elsewhere) for ARRL membership dues for one year. Start *QST* with the ....issue. I prefer a membership ☐ certificate ☐ card.

Name .... *Call (if any)*..........

Street and number..

City .... *Zone* .... *State*..........

IN THE PROPER ORDER . . .



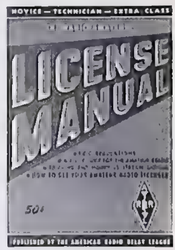
25¢ Postpaid.
No stamps, please.

LEARNING THE RADIOTELEGRAPH CODE

FOR those who find it difficult to master the code, this ARRL publication supplies the key to the problem. It is designed to help the beginner overcome the main stumbling-block to a ham license. The pitfalls are pointed out, and he progresses step by step toward a faster knowledge and ability to send and receive in code. When code practice machines or experienced operators are not available, "Learning The Radiotelegraph Code" is a boon to the Novice. Material is included on practice, both classroom group study, and home-study as well. There are also data on high-speed operation, typewriter copying and general operating information as well as tables and references.

THE RADIO AMATEUR'S LICENSE MANUAL

COMING off the press almost as fast as the demand for it, which is enormous, the Radio Amateur's License Manual has become one of the most important publications of The American Radio Relay League, especially since the Novice, Technician and Extra Class licenses were approved by the FCC. The License Manual is the What, Why, and Where for the ham who is seeking to get that coveted ticket. Practically everything he needs to know is contained in this concise, clearly-written text. A popular guide post to a ham ticket for many thousands every month. It is completely revised and includes the latest FCC regulations.



50¢ Postpaid.
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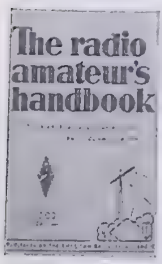

$3.00 USA Proper.

THE RADIO AMATEUR'S HANDBOOK

THE recognized reference work of radio amateur and electronics engineer, this annual ARRL publication ranks ace-high in popularity. It finds its way to the desk of the engineer, technician, laboratory man, equipment designer, amateur. The engineer and the purchasing agent of many concerns find it indispensable for checking and securing data, gear, equipment and components. There is hardly any query that might possibly arise in ham radio which is unanswered. Written in a clear, concise manner, and illustrated with hundreds of sharp photographs and clear diagrams and schematics, The Radio Amateur's Handbook is proving a godsend to many thousands who are building, repairing or improving their present rigs; to others who seek knowledge or news of new developments and new products. Chapters are devoted to Theory, Construction, Components, Functions, of various parts; wave propagation, Antenna Systems, TVI, H.F., V.H.F., Modulation, Reception and Transmission, Trouble-shooting, Power supplies, Microwave Communication, Mobile Equipment, Measuring and Test Equipment, Putting a Station on the Air, Proper Operating Procedure . . . The Handbook contains complete charts and tables of tubes, values and radio terms. Many months of intensive work annually go into the preparation of the Handbook.

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The AMERICAN RADIO RELAY LEAGUE, Inc.

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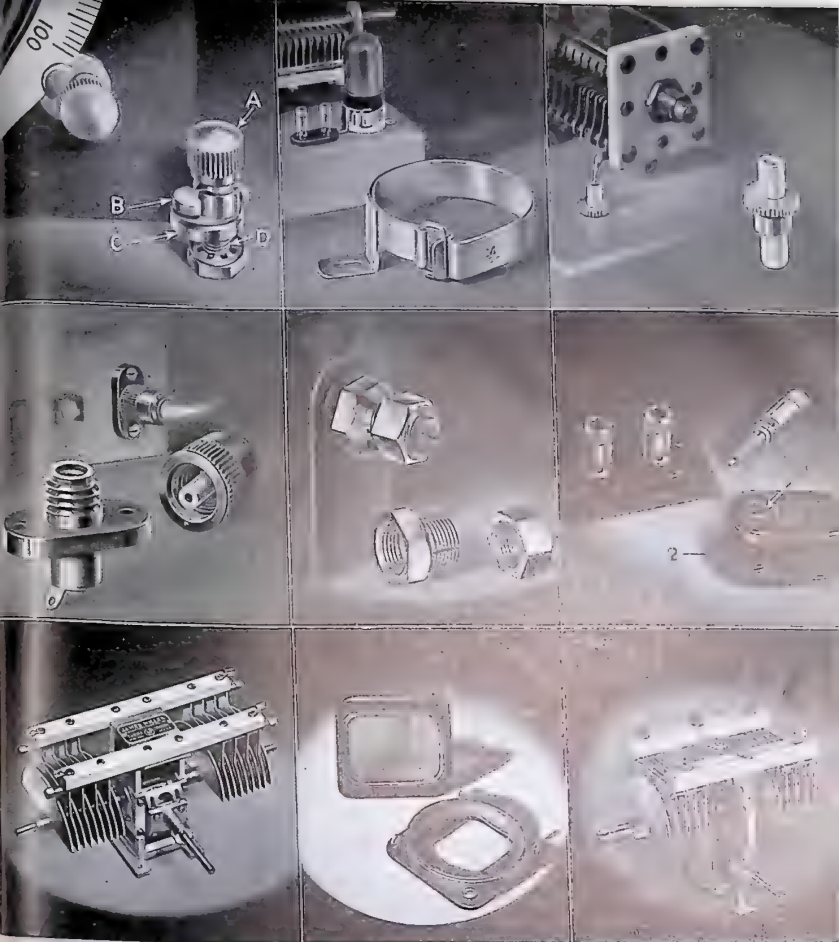

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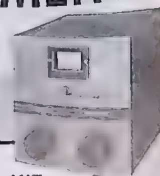

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The JOHNSON VFO kit is accurately calibrated for all amateur bands from 10 to 160 meters. Stability is excellent, assured by rigid construction and temperature compensated ceramic padders. Vernier tuning, clean keying, and perfect "break-in" on all bands. Assembly is simple. Kit complete, less tubes.

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SEMI-AUTOMATIC KEY WITH SWITCH

Compact, light model. Circuit closing switch. Die cast base, 6"x2¾"x¾". Black wrinkle enamel finish. ⅛" coin silver contacts. Fully adjustable from eight words per minute to highest rate desired.

Cat. No. 114-510 . . . . Net Price $10.50

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Heavy die cast base. Smooth adjustable bearings. Provision for plugging in semi-automatic keys. ⅛" coin silver contacts. Operates with a light keying touch.

Cat. No. 114-310 . . . . Net Price $3.00

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An inexpensive practice set for beginners. Constant frequency buzzer and key mounted on a 4"x6" molded brown Bakelite base. May be used singly or in pairs for code practice.

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Complete information on JOHNSON semi-automatic, standard and practice keys included in General Products Catalog 973. Write for your copy today!

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40 to 50 Watts — 8 Bands — Phone or CW
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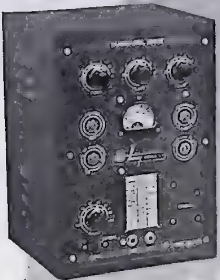
80, 40, 20, 15, 11, 10, 6 and 2 Meters
(completely wired and tested—not a kit)



BANDMASTER SENIOR

A complete ready to go transmitter including the new crystal-oscillator-vfo switching circuit. Phone or CW — Eight bands — 80, 40, 20, 15, 11, 10, 6 and 2 Meters. Ideal for either mobile or fixed station use. Will operate from A.C. power packs up to 450 volts at 275 ma., vibrator supply or dynamotor supply for portable mobile operation. Employs Pi antenna matching network. Power input to final is 50 watts with 450 volt power supply on Bands 1 through 7, 30 watts on Band 8. No tuning adjustments are necessary except those required to resonate the final output to the antenna. May be mounted on rack panel with power supply. For use with carbon microphone. No plug in coils .. **$111.50**

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Has built-in three tube preamplifier for use with crystal mike, and ALL the features of the Bandmaster Sr. **$137.50**

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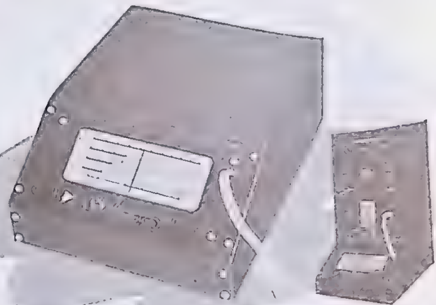
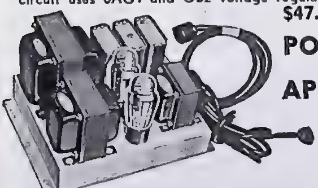
Designed specifically for the Harvey-Wells Bandmaster, but may be used with all types of transmitters. Extremely stable — both electrically and mechanically — rugged tests produce no loss of power or frequency shift even on 28 mc. Slanted, illuminated dial face provides ease of operation and full visibility. Cabinet styled specifically to save valuable space in the shack. Your Bandmaster and VFO become an integral unit. 300 ohm output plugs into crystal socket. The Bandmaster VFO has been designed to meet the flexible requirements of today's versatile amateur. Six bands — each directly calibrated on the oversize slide rule dial — provides 20-25 volts R.F. output over entire frequency range, measured across the 6AQ5 in the transmitter oscillator — Plate and heater voltages are obtained from the terminal strip on the transmitter. Power requirements are 6.3 v @ 0.65 amps. and 300 v @ 30 ma. Highly stable Clapp type oscillator circuit uses 6AG7 and OB2 voltage regulator. **$47.50**



POWER SUPPLIES

APS-50



Delivers 425 v. at 275. ma. and 6.3 v. at 4 amps. May be mounted on rack panel. For 110 Volt A.C. 50-60 cycles **$39.50**

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A dynamotor supply for portable operation.
Delivers 300 Volts 250 ma.
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For 12 Volt operation **54.50**
(400 Volts 250 ma.)

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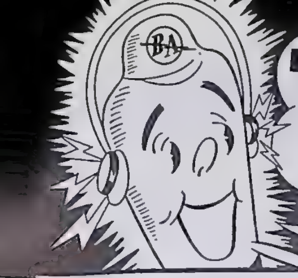

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Kit consists of a compact, fully enclosed Power Transformer, pri: 117 V. 60 cycle AC 110 V @ 40 MA. H.V. Sec., and 6.3 V @ 1 amp. for filament. A 35 MA-130 V. Selenium Rectifier and a 16 Mfd-150 V. DC wkg-225 V. peak electrolytic Filter Condenser . . . both very compact and easy to mount with the tinned wire leads. Wt 1½ lbs.

You Get All Above
No. 14B993. PER KIT $1.79

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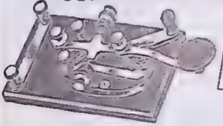

95c

Top quality key, priced at a fraction of original cost. Mounted on bakelite base, ¼ x 4¾ x 3". Fully adjustable, well balanced operating lever. Has positive contact shorting spring. Contacts are of high grade tungsten and securely fastened. Ideal for keying amateur transmitters.
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Special, Each 95c

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IN REGULAR FT243 HOLDERS

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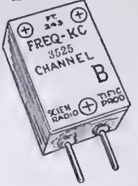

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You can easily change frequency if necessary by following crystal grinding instructions in any handbook.

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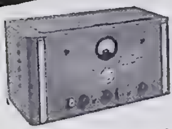

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A beautiful, compact XMTR, completely self-contained, including power supply. Covers 160M thru 10M. Complete kit includes all parts, chassis, panel, power supply, cabinet, tubes, meter and one set of coils.

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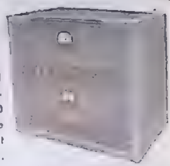

R. F. Section a complete 165 watt XMTR. Provisions for ECO. Automatic fixed bias on Final and Buffer. Class B Speech Modulator. 165 watt input — 10 thru 160 meter bands. Complete with tubes, meters, and one set of coils. Low Down Payments.

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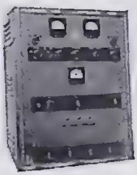

Our new, 1953 model is the last word in a compact, well engineered transmitter—400 watts phone, 435 watts CW. TVI suppressed. Efficient performance on all bands—10 thru 160. Provisions for ECO or VFO. Complete with tubes, meters, and one set of coils.

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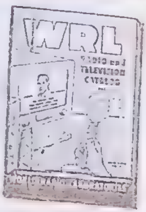

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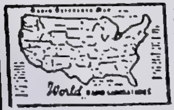

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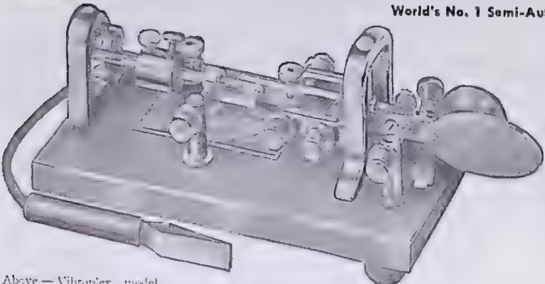
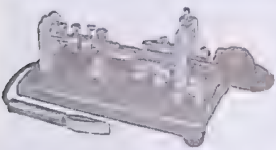


Above — Vibroplex model **Presentation** Suits any hand. Wider speed range. Needs no additional weight for slowest keying. This key has a "touch" that lessens arm fatigue and makes keying easier than ever before. Richly finished in polished chromium, red trim and 24 K gold-plated base top. It is a revelation to everyone who has used one. . **$29.95**

Sends Better
Sends Easier
Sends Faster
Lasts Longer

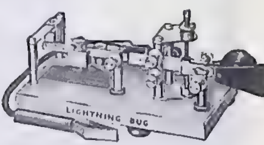
Until you've used a Vibroplex key you've no idea how easy sending can be. Vibroplex brings to you the simplicity, ease of operation and machine speed which makes keying a pleasure instead of a task. No other key gives Vibroplex amazing keying performance, or is so easy on the arm. Preferred by professionals and amateurs the world over.

Standard —
Black crystal base
DeLuxe —
Polished chromium base and parts, red trim, jewel movement



Vibroplex model **Lightning Bug** — Has many advanced features which contribute to its remarkable ease of operation and professional performance. Maintains clear, snappy signals at all speeds. A popular choice

Standard.................. **$15.95**
DeLuxe **$21.50**



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Standard **$17.95**
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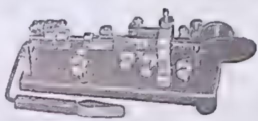

Vibroplex model **Blue Racer** — Only half the size of the Original, yet operates with the same ease and perfection as that famous key. Weighs 2 lbs. 8 oz. Occupies small space. In high favor with radio men.

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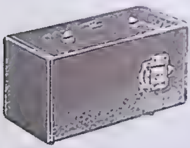

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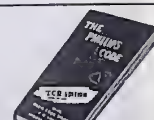

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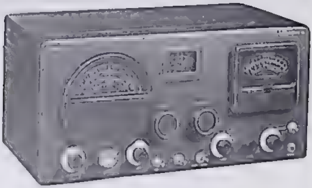

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